The
Practical Engineer

A monthly journal, devoted to the economical generation and utilization of power and to the interests of stationary engineers

VOL. XI. PHILADELPHIA, APRIL, 1907. No. 3.

BRUSH HOLDERS FOR DYNAMOS AND MOTORS

BY W. H. WAKEMAN.

Fig. 1 represents a brush holder that is designed for a long carbon brush, and only a long one can be used in it. When we look at such a brush it appears as if it would last a long time, but this depends on the brush holder, for if it is located several inches away from the commutator, as shown in the

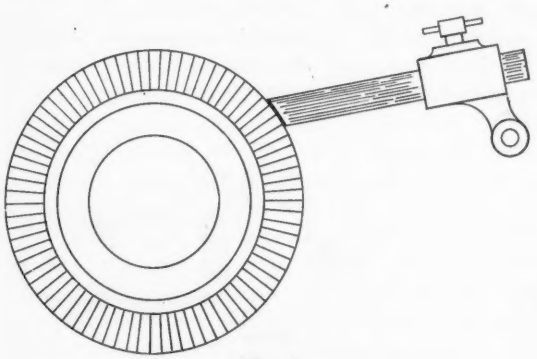


Fig. 1

illustration, it will last no longer than a much shorter one in the holder illustrated in Fig. 2, as it is located near the commutator, hence the extra length of brush appears at the outer end of the holder, but it can be set inward to compensate for wear, until about one-half of it is actually used, thus proving both convenient and economical.

When a brush that is set at an angle to the commutator wears on account of long use, the angle of contact is changed, also the actual position of the brush in relation to the field coils is different from what it was when the brush was long. If the brushes wear evenly the distance between them will not change, therefore the centre of the point of contact of one will remain at 90 degrees from the next one to it in either direction, on a four-pole dynamo or motor, but the entire set should be turned a short distance in the direction that the armature revolves, in order to restore them to their original position in relation to the field coils.

Fig. 3 represents a flexible brush holder in which the position of the brush never changes from the time that it is put in new and long until it becomes old and short. This illustration shows a long brush in use, but Fig. 4 is the same brush after several months of service. It is now short, but the flexible upper and lower parts have maintained the same relative position, hence the brush has traveled straight toward the centre of the commutator.

When the brush shown in Fig. 2 has become worn from long use, it is in contact with more surface on the commutator than when new, therefore some engineers recommend us to reduce this contact by filing; but there appears to be no good reason for this that applies to nearly all cases. Only a narrow strip of such a brush is fitted to the commutator when new, but this is extended as the brush wears, which fact explains why the surface in contact is increased. Does anybody make a practice of filing the brush in Fig. 3 until only a portion of its end touches the commutator? If so, it is not generally known and imitated, and there is no good reason why it ought to be.

Of course, we can imagine a brush so thick that it would touch more segments of the commutator at once than it ought to, but its size would prove very uncommon. As a carbon brush is very stiff and unyielding when compared with a cop-

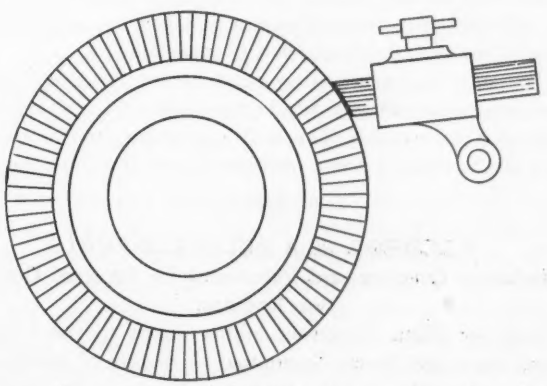


Fig. 2

per brush, where the former is used it is necessary to keep the commutator in perfect order as there is nothing to compensate for slight inequalities, and a thin brush will not touch so many at once as a thick one, which is a good argument in favor of thin brushes; but if a commutator is frequently ground down

by a piece of sandpaper on the concave side of a block of wood that is nicely fitted to the circle it describes, there will be no high places to cause sparking with any kind of brushes.

Another advantage of the kind of brush holder illustrated in Fig. 3 is that the commutator may be run in either direction with equal satisfaction. For ordinary use this is not of much account, but when a new dynamo arrives at a plant, and owing

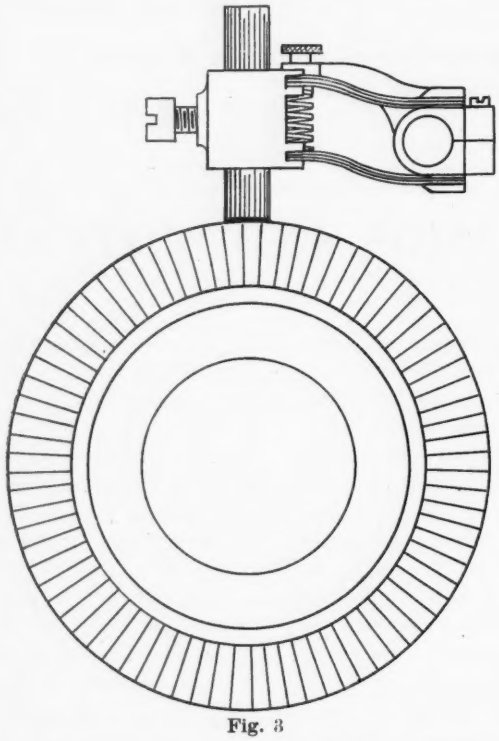


Fig. 3

to local conditions it must be run in the opposite direction from its original design, the above-mentioned feature is valuable, also where a dynamo is moved and placed so that its direction of rotation must be changed in the new location.

Brush holders should be designed to carry two or more brushes side by side, rather than for one large one, so that in case of emergency one section can be taken out at a time and replaced without shutting down the machine.

They should also be made so that the brushes can be raised from the commutator, quickly fastened away from it, and easily let down when wanted. This will be a convenient feature when using the sandpaper above mentioned, and at other times.

ALCOHOL AS A RELIABLE FUEL.

Superior to Gasoline and Petroleum for Internal Combustion Engines.

Professor Elihu Thomson, in his report to the Congressional Ways and Means Committee on the use of alcohol as a motor fuel, said: "Our experience developed the fact that alcohol is suitable as a motor fuel even when it contains as high a percentage as 15 per cent. of water. Notwithstanding the fact that the heating value of alcohol or the number of heat units contained is much less than that in gasoline, it is found by actual experiments that a gallon of alcohol will develop substantially the same power in an internal combustion engine as a gallon of gasoline. This is owing to the superior efficiency of operation when alcohol is used; less of the heat is thrown away in waste gases and in the water jacket.

"The mixture of alcohol vapor with air stands a much higher compression than does gasoline and air without premature explosion, and this is one of the main factors in giving a greater efficiency. It follows from this that, with alcohol at the same price as gasoline, the amount of power developed and the cost of the power will be relatively the same so far as fuel itself is concerned, but on account of the higher efficiency of the alcohol less cooling water is required, or a less percentage of the heat of combustion is communicated to the cylinder walls of the engine. The exhaust gases from the alcohol engine carry off less heat. They are cooler gases.

"It is well known that the exhaust gases from a gasoline or kerosene engine are liable to be very objectionable on account of the odor. In our tests there is absolutely no such objection with alcohol fuel, the exhaust gases being but slightly odorous, or nearly inodorous, and what odor there was was not of a disagreeable character. Our experiments with the burning of alcohol as a motor fuel also showed us that alcohol possesses a considerable tolerance as to the richness of the mixture in the engine, and that even when there was considerable excess of alcohol for the air the exhaust was not disagreeable in odor, a condition which, with either gasoline or kerosene, leads to a smoky, badly-smelling exhaust. The importance of a fuel which does not produce disagreeable exhaust gas is greatest in the case of stationary engines of considerable power, as in that case the exhaust is emitted in one locality and

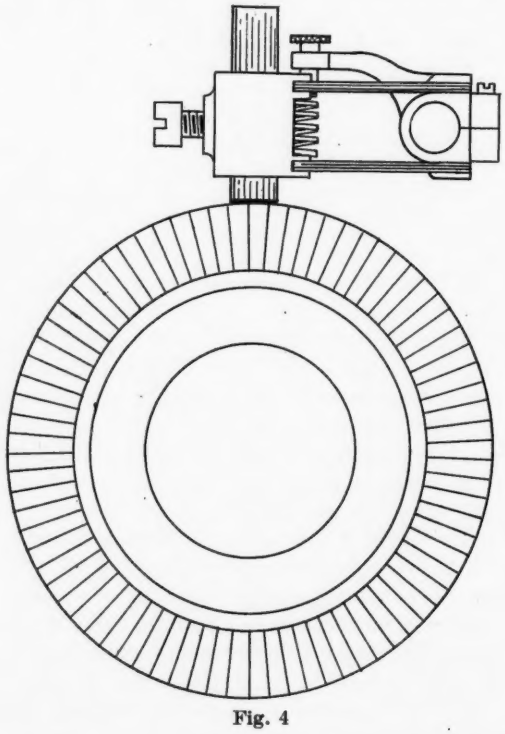


Fig. 4

may become a source of nuisance. This has often been experienced with gasoline or kerosene engines and has tended greatly to limit their application, particularly in densely built-up sections."

RECENT DEVELOPMENTS IN CENTRAL STATIONS

Type of Prime Movers, Methods of Power Distribution and Power Plant Design Intelligently Discussed

At a recent meeting of the Engineers' Club, of Philadelphia, Mr. Thomas C. McBride, the retiring president, read an interesting paper on the recent developments in large central electric plants. The great strides which have been made during the past decade in stationary engineering and in the transmission of power are clearly brought out in this paper, and considering that most of the great improvements are mere infants in point of years, a review of these important changes shows how rapidly the American engineer makes use of new inventions and applies them for the betterment of the power plant and the increasing of its efficiency. Mr. McBride's paper follows in part:

"The last few years have seen a very rapid development and some radical changes in large American central electric lighting and electric railway power plants, producing their energy from coal, that seem worthy of more than passing attention. Only six years of our new century have passed, yet the power plant built to-day is entirely different from the plant of the last century. A review of progress in the design of the complete plant necessarily covers a very wide engineering field and so many details that only the more important of these details can be considered, and those but briefly. Much of this development has had in view lessening the cost of the production and distribution of electric energy, but considerable of it has been forced on the power station situation by a very rapid increase in the demand for electric power and light.

"A complete change in the general scheme of the distribution of electric energy from that which was usual ten years ago has been the principal cause of the very rapid development of the modern 'central' electric power plant. Possibly six years ago, surely ten years ago, over three-quarters of the electric energy generated from coal was distributed in the same form in which it was generated and used. An incandescent lighting system meant 110 or 220 volts or thereabouts generated in the station, distributed on the lines and used in the lamps or motors, and a circuit reaching out a mile was considered as much as it was advisable to attempt. Trolley work meant 500-volt generators, feeders, and lines, and arc lighting meant just as surely constant current, series distribution. The interior of a power house for any one of these systems indicated exactly which service it was supplying. These power plants were necessarily located near their load centres, and we therefore find them in the midst of residence and business districts, central in fact as well as in name. It seems rather remarkable that so many of these plants have been located at points requiring the carting of coal, and out of reach of condensing and cheap feed-water supply when other locations but a few hundred feet away would have given them a conveneint supply of both fuel and water, indicating that the builders of these old plants either did not appreciate the advantages of convenient fuel and water supply, or else did not anticipate a growth to a size where their hauling bills or the economies of condensing operations would be worthy of consideration.

"The interior of the great 'central' power stations we are building to-day gives no indication of the particular service for which their energy is being used. Power for railway, incandescent, or arc lighting is generated in the form of high potential alternating electric current, and distributed to sub-stations where it is transformed into the particular kind of current desired. The incandescent station and the trolley station with their heavy investments in copper and the arc station with its jack shafts; belts, and large number of small machines have given way or are giving way to the alternating current station with its uniformity of plan and construction which seems to be gradually reaching a standard form. The high potential at which these modern plants distribute their current not only permits of their location where fuel and condensing water supply are convenient, but also enables them to cover economically larger area and distances, permitting the replacement of a number of smaller plants by a single large plant with all the attendant economies in first cost, maintenance, and operation.

"The change from the old system to the new, with its high tension alternating current, afterwards transformed for its own particular use, seemed to set in most rapidly about the beginning of our century. The alternating current had long been acknowledged as preferable for distribution, but trouble in paralleling generators had prevented its extensive adoption. It will be appreciated that successful parallel operation is necessary for economy, not only in generation, but also in distribution of electric energy. Generators must operate successfully in parallel if they are to be loaded to their best efficiency, and if an efficient and simple system of distributing mains is to be employed. Attempts to use a very high frequency seem to have been the principal cause of the difficulty with parallel operation in the early years of the alternating current. Fifteen to eighteen years ago 133 cycles was usual. That engineers were not sure of the success of parallel operation of 60-cycle alternators even with belt-driven machines at the time of the Chicago Exposition is evidenced by the fact that the lighting plant of the Exposition, consisting of ten 750 kw. 60-cycle 150 R. P. M. generators, was deliberately arranged not to run in parallel, at considerable extra expense for an elaborate switchboard permitting any unit to be connected to any distribution main.

"The starting of the Niagara Falls Power Company's plant in 1895 marked an epoch in the history of the distribution of electrical energy and established parallel operation with 25 cycles as a commercial success. Even up to a few years ago parallel operation with 60 cycles was difficult and often the cause of much trouble. Recent improvements in generator design have secured successful and reliable parallel operation at 60 cycles, and proven this success to be largely an electrical matter and not entirely dependent on uniformity of angular velocity of the prime mover, as was thought a few years ago. Whether this success will result in the more general use of 60-cycle frequency with polyphase currents in power distribution will doubtless be decided in the near future.

"The maximum voltages of the distribution system of the

few large American coal-electric alternating current power plants in existence at the beginning of our century, barring one or two exceptions, was 6,600. The Metropolitan Street Railway, New York, power house, and the New York Edison power house at Thirty-ninth Street, are examples of plants of the kind under consideration that were using this voltage. The Manhattan Railway Company plant, started in 1901, nearly doubled this amount, distributing at 11,000 volts, and the direct generation of this voltage on the dynamos was considered a very striking electrical feature. Since the Manhattan there has been practically no increase in the voltages adopted for the distribution systems of the railway and lighting plants of our largest cities receiving their current from power stations within them; 13,200 volts being the maximum in use for this class of service. As it is altogether likely that 11,000 to 13,200 volts will remain the maximum for distribution over the area of our large cities because these pressures are ample for economy and offer the advantage of safe direct generation, it is much to be regretted that some standard figure was not adopted long ago for the sake of simplicity in the manufacture and operation of electrical machinery.

"The coal-electric power plant has recently been called upon to deliver electric energy over long distances in a number of heavy electric traction projects. These distances have been so great that voltages as high as those until recently found only in our hydro-electric long-distance transmission plants have been necessary. The coal-electric power station and the high-voltage, long-distance transmission line, although developed separately, have each been developed so well that the success of their combination has been a foregone conclusion. There is now no difficulty in securing well tried out electrical apparatus which would operate economically 100, 200, or even 300 miles of railway from one power house. Projects like that proposing to generate electric power for cities like Philaphia and New York at the coal mines seem quite feasible if only a sufficiently large market for the power is obtainable. The coal bills of large 'central' stations in these cities represent about 70 per cent. of the cost of energy at the switchboard, not including fixed charges. About two-thirds of the cost of the coal is freight. Fixed charges and many of the other expenses of operation would be considerably less in the open country than in our large cities. It may therefore safely be concluded that power can be produced at the mines for less than 50 per cent. of the cost of its production in the cities mentioned.

"It is likely that 50,000 volts, or thereabouts, will be more than ample pressure for most projects of distribution from coal-electric generating plants, as this will economically cover a radius of, say, 150 miles, but occasional coal-electric projects are not unlikely to present in the near future, as hydro-electric projects are now presenting problems whose solutions will be dependent upon a cheaper and more efficient method of transmission than is obtained with the voltages with which we are now familiar. Present knowledge indicates that this can only be obtained by largely increased pressures. Problems like Victoria Falls, talked of so much abroad, call for 100,000 to 150,000 volts. Electrical manufacturers have already catalogued and are ready to supply switches and lightning arresters for 125,000 volts. Experimental lines carrying 100,000 volts have been tried in Europe and found practicable. The maximum of 40,000 volts in 1901, with a year or two pause at 60,000 volts, has now gone to 75,000 volts at the Edison Company, California, plant. There are so many opportunities for considerably higher voltages than the present maximum that a much more rapid increase in the maximum voltage may be looked for in the next few years.

"The general scheme of distribution by the alternating current as used by most of our large 'central' electric power plants involves so many transformations of energy from one kind to another that it is far from ideal. The complication of the system of the distribution of power by the alternating current is so great that a grave question has arisen as to just how the load, particularly of a large lighting system, could be promptly picked up again if for any reason the entire system was shut down even for a moment. Considering these complications it is small wonder that a few plants, even some of large size like the Boston Elevated Railway Company's system, continue to use and to increase their number of small direct current stations.

While the complexity of the distribution system required for most alternating current plants is a disadvantage, the ease with which the potential of the alternating current may be stepped up or down without rotative machinery and of transformation of one supply current to a variety of forms, together with the possibility of generation at high potential, make it altogether likely that the ratio of the alternating current used for distribution as compared to the direct current will continue to increase even more rapidly than in the last few years.

"Sub-stations are demanding increased attention on account of the great amount of machinery in them and their frequently being supplied with storage batteries. Many recent sub-stations are of very large size, some as large as the average central station of the last century; in fact, many old central stations are now used as sub-stations, their original machinery being held as reserve.

The sub-stations of the N. Y. C. & H. R. R. and the West Jersey & Seashore are examples of modern sub-stations for heavy electric traction, and illustrate the great amount of power now being distributed by their means. Two of the former have each three 1,500 kw. rotary converters, the balance three 1,000 kw. and all have room for two more. These sub-stations each have storage battery equipments designed not only to take the fluctuations in the load, but large enough to run the system for one hour. One of these batteries has a discharge rate of 4,020 amperes, another 3,750, another 3,000, and the remaining stations 2,250 amperes. These sub-stations receive three-phase 25-cycle current at 11,000 volts, and deliver 666-volt direct current to the third rail. The West Jersey & Seashore sub-stations receive three-phase 25-cycle current at 33,000 volts, and deliver 650-volt current to the third rail. These sub-stations generally have each two 750 kw. rotaries with room for a third.

"Storage batteries, although vigorously condemned by many, are being more generally adopted and are rapidly assuming an important place in the organization of large lighting and railway plants. The usefulness of the storage battery has been much increased, particularly in the last year, by a great increase in the possible discharge rate for short periods, and some very large storage battery plants have recently been installed. Storage batteries are used as a reserve supply of current for excitation and to carry peaks, and have been installed in some cases with a capacity large enough to act as

a reserve supply for the station itself should either all or part of its machinery or its distributing mains be out of commission. With modern rotaries, sub-station batteries will return power to the alternating mains when the power station itself or other sub-stations are in need of assistance. The storage battery in connection with automatic boosters and rotary converters is being used to even the load on power stations as a means of increasing their economies of output and first cost, and it is now claimed that storage batteries with modern machinery can be regulated so that the call on the power station will vary but a few per cent. in spite of enormous fluctuations of the final load.

"It is not at all unlikely that the near future may see the storage battery applied to strictly alternating current plants. The present year will be rich in developments of alternating current traction, and where railways may need sub-stations with step-down transformers at distant points, it is not impossible that it would be advisable for these distant stations to be supplied with batteries and rotaries that will run inverted, and also, possibly, automatic boosters. Such an arrangement would not only permit of the distant sub-station furnishing for a short period of time a relatively large amount of power, even though supplied through a small line, but would also insure the supply of power for a short time in case the line had failed.

"The prime mover question has without doubt furnished the most interesting power station development of our new century. We started our century with our old friend, the steam engine, in complete possession of the field, one hundred and twenty-five years since Watt, almost sixty years since Corliss had given the steam engine a place which seemed impregnable, yet our twentieth century, with a thought though many times older, but until 1884 unstudied by modern science, has given the steam turbine of to-day a place beside, if not ahead, of the steam engine for central power house work, made a good start with the large gas engine and started serious study of the gas turbine.

"The first year or two of our century witnessed remarkable developments in the steam engine field, in the rapid increase in size of units. The two 4,000 horse power engines for the Bay Ridge Station of the Kings County E. L. & P. Co., started early in 1901, were considered large units, but were rapidly followed by 5,000 horse power units for the Kingsbridge Power House of the New York Metropolitan Railway and the Boston Elevated, and the eight 6,500 horse power engines for the New York Edison, and before the end of 1901 the first 7,500 horse power unit of the Manhattan Railway Company had been started.

"A number of engines of the same general type and size as the Manhattan have since been built, notably nine for the New York Subway power house; but no engines of any greater capacity for power house work. These engines probably represent the final development in size of the steam engine for electrical power house work. Of 7,500 H. P. at best efficiency and 11,000 maximum H. P. they were guaranteed not to require more than 12¼ pounds of steam per I. H. P. at nominal rating with 175 pounds saturated steam and 26 inches vacuum.

"The steam turbine was not known in the American 'central' power station in the last century. During April, 1901, a 1,500 kw. Westinghouse-Parsons turbine was started in Hartford, Conn. Since 1901 the use of the steam turbine has become almost universal, and but few large steam engine units have been ordered for large 'central' power plants. The report of the turbine committee of the National Electric Light Association for June, 1905, states that there were then in operation 225 turbines of a total of over 350,000 kw. capacity, and that the total capacity shipped or on order June, 1906, was about 931,000 kw. As this figure is about equal to the total central station alternating current generator capacity of the country stated by the U. S. Census for 1902, it presents a remarkable showing. Almost without exception large new power stations, as well as any large additions to old stations, are being furnished with turbines, and during the last year or two we have seen the advent of turbine-driven station auxiliaries. Turbines as large as 9,000 kw. nominal capacity have been running for some months and 10,000 kw. turbines are being built.

"The advent of the steam turbine has developed the use in the United States of the super-heater, and of a special form of condenser for high vacuum. This high vacuum has required at least twice the amount of condensing water needed for the vacuum usual with the steam engine, and all the extra cost of conduits, pumps, etc., to handle it. While the turbines themselves require practically no constant attention, the auxiliaries necessary are so large and numerous that their cost for attendance and oil is considerable. Notwithstanding all this, the low first cost, the low steam consumption through a wide range of load, the high rotative speed and uniform angular velocity, the small floor space and foundations required, and the simplicity of the steam turbine have in a very few years made it for electric work the prime mover of to-day. The large steam turbine has become such a familiar sight in central electric power houses that it seems scarcely possible that it is only three years and three months since the first 5,000 kw. turbine was started in this country. This machine was started in the Fisk Street Station of the Chicago Edison, October, 1903, and followed in a few months by another. The next 5,000 kw. units to be started were at the Boston Edison; one in October and another in November, 1904.

"The rapidity of the successful development and introduction of the steam turbine in this country has earned great admiration for those in charge of this work. Considering the amount of money involved, their confidence in their calculations, often made with little experimental basis and, in the face of predictions of failure from not a few engineers of note, must have been absolute.

"The large gas engine has not yet made any impression on strictly 'central' station practice in the United States. Electric stations with units up to 500 H. P. are in successful operation, mostly furnishing power for electric railways, and are said to be doing very satisfactory work. The only large gas engine as yet started in 'central' station work of which the writer is informed is one of the lot of four 5,400 H. P. engines furnished the California Gas & Electric Corporation by The Snow Steam Pump Works. Three of these engines have been erected in San Francisco and the fourth is being shipped to Oakland. The first of the San Francisco engines has been operating very satisfactorily, carrying loads approaching its full load in parallel with water wheels and a steam plant owned by this corporation. The builders of these engines state that the starting and operating of this engine and the recent start-

ing of the second engine has been more satisfactory than they even dared to hope, particularly in view of the kind of gas used.

"An investigation of the present status of the large gas engine in the United States indicates that it is well worthy of consideration for 'central' power station work. It is not generally known that the large gas engine is already well developed in this country, but it is a fact that a number of large engines have been in successful operation for some years. The first of these large engines were built by The Snow Steam Pump Works, who have built and in operation, or about ready to start, 53,400 B. H. P. of gas engines, and have in various stages of completion 50,450 B. H. P., ranging in size from 60 to 3,300 B. H. P. Some of their large engines have been in service since 1900, two 4,000 B. H. P. engines have been in service since the summer of 1904. Several record runs of 50 to 90 days without a shut-down have been reported, performance which would not now be considered exceptional should circumstances warrant so long a continuous run.

"The gas engine plant of the Lackawanna Steel Company at Buffalo with its 32,000 H. P. in blowing engines and 8,000 H. P. direct connected to electric generators has been in operation for two or three years. The blowing engines are of 2,000 H. P. each and the direct connected engines 1,000 H. P. each.

"No greater index of the confidence of engineers who have investigated the large gas engine in its future can be found than in the greater number of large engines that have recently been ordered. The engineers are fully satisfied that the large gas engines can be depended upon for satisfactory continuous operation is demonstrated by such orders as that of the U. S. Steel Corporation for its new steel plant at Gary, where continuity of operation will be vital.

"As is usual with large gas engines, these engines are designed for peak overloads of 15 per cent. above the nominal rating stated. This method of rating reveals a limitation of the gas engine, not to its advantage compared to the steam turbine, the latter being ordinarily so rated that it is capable of carrying 50 per cent. over its nominal rating for two hours, and 100 per cent. over for 'swings.' The possibility of starting the large gas engine in a minute or so however overcomes this objection for all considerations, except that of the greatest loads the station can carry regardless of economy of operation or where it is absolutely impossible to predict very large sudden increases of load. As it is generally possible to predict well in advance the greater load fluctuations of any station, this feature can be neglected, and it is necessary in comparing first costs per kw. nominal capacity only to consider the station as to the maximum total loads it will carry. On account of the small range of overload capacity of gas engines, they are generally provided with generators of somewhat lower nominal rating than their engines, and the 100 per cent. overload 'swings' of turbine practice cannot therefore be applied in comparing the nominal rating of the gas engine. As the gas engine is capable of operating indefinitely at 15 per cent. over nominal rating, it seems only fair that this overload rating should be compared with the 50 per cent. for two hours overload capacity of the steam turbine; in other words, that for comparison of first cost of gas engine and steam stations on the basis of the maximum loads the stations can carry; the gas engine should be considered of only $115/150 = 76.7$ per cent. of its usual nominal rated capacity. On this basis the first cost of the gas engine station assumed would vary from $\$90.98 \times 150/115 = \$118.94$ to $\$80.50 \times 150/115 = \$105.00$. It is evident that these figures should not be used for comparison, but instead the cost per nominal kw. capacity of the gas engine and the steam turbine plant be compared where the load will not vary more than 15 per cent. above normal, and it is desired to load either the gas engine or the steam turbine to the point of maximum economy.

"Boiler practice, except for the introduction of the superheater, has changed less in the last six years than any other part of the power plant. Steam pressure as high as 175 lbs. were in use at the beginning of our century and the maximum is now 200 lbs. The maximum steam temperature obtained in this country is about 500° Fahr., not nearly as high as the maximum temperatures in use in Europe, and with this temperature no trouble whatever is experienced in steam turbines, nor, with a little care in the lubrication and packing, in the auxiliaries. The size boiler units generally used still varies from 500 to 650 H. P., but some exceptional units said to be of 1,000 H. P. capacity have been installed. It is now realized that the boiler room is the largest part of the modern plant, and that any further reduction in size of building and ground space must be effected in the features of the boiler room. Many of our designers seem to have gone to extremes to save ground space, even at the cost of sacrificing convenience of access and operation, and in spite of the fact that particularly with high tension transmission land is often cheap and many times a paying investment; but the indications are that larger boiler units may in the future be used as a method of decreasing first cost.

"Automatic stokers are now almost universally used where soft coal is burned, and coal is as universally handled entirely by machinery. One large plant has a coaling station capable of removing 700 tons of coal an hour from barges.

"Screwed steam piping and fittings have given way to superior constructions. Cast steel fittings are used almost universally, and the pipe flanges are either steel forgings into which the pipe is rolled or else forged directly on the pipe itself.

"Switchboards have dwindled to control boards, operating the switches from a distance through electrical or pneumatic means.

"The antiquated, though not old, stations of the last century seemed to be a gradual growth. Their different units installed at successive periods were often a tangible commentary on the history of the art of generation and distribution of electric power, and almost universally these units were intentionally an assorted lot of different sizes. While the art has not yet reached a definite state, and its development is still advancing probably at fully as rapid a rate as has been experienced in the last six years, this century's demands for power have been so great and come on us so quickly that we have rushing to completion stations of as much as 30,000 kw. capacity, and the stations themselves instead of the units in them, may be taken to indicate the state of the art when they were planned. The different machines in the old stations used to be our units of study, thought and comparison; now our units are whole stations. The central power plant of to-day is the subject of very careful engineering study and investigation, and has very properly come to be looked upon as a unit of itself—a complete machine designed to take coal in one end and deliver electric energy at the other."

Vertical Turbo-Alternators in American Stations

By Frank C. Perkins.

The turbine alternator is now being utilized in the principal electric light and power stations throughout the world and is generally considered as one of the most economical prime movers operated by steam to-day when installed under the *most favorable* conditions. The horizontal steam turbo-alternator occupies much less space for a given output than the reciprocating engine either of the vertical or horizontal type, and the vertical steam turbine and vertical generator mounted on the top still further economizes space.

The steam turbines are found to be most satisfactory for variable loads, the turbo-alternators taking the peak of the load in a central station very much as a storage battery would, leaving the reciprocating engines working at nearly a constant output.

Among the important Edison central stations using vertical turbines and alternators may be mentioned those of Los Angeles, California; Chicago, Ill; New York City and Boston,

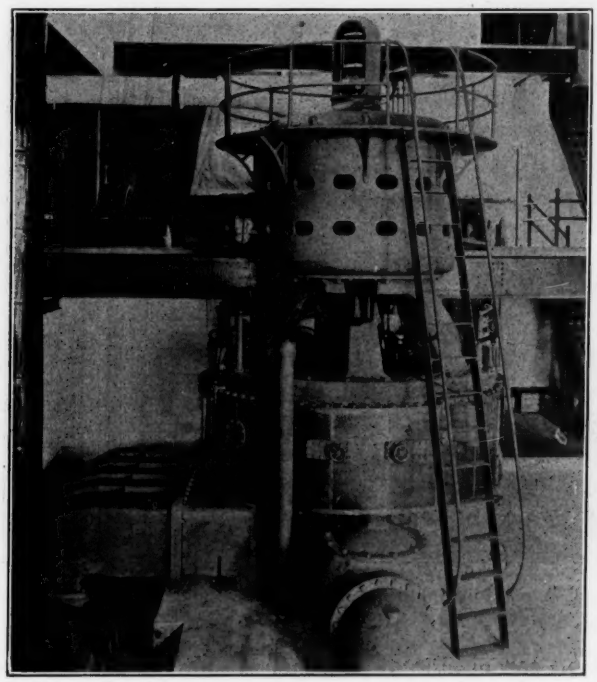


Fig. 1—2300 Volt Turbo-Alternator at the Edison Co.'s Plant at Los Angeles, Cal.

Mass. The accompanying illustration, Fig. 1, shows one of the 2000 kilowatt Curtis turbo-alternators of the four-stage type installed at the Edison Electric Co.'s central station at Los Angeles. These vertical turbine units supply a three-phase current of 2300 volts pressure having a frequency of 50 cycles per second. These machines operate at a speed of 750 revolutions per minute and are in service in parallel with generators driven by water power located in hydro-electric stations 83 miles away from the steam turbine plant. The alternators are of the 8-pole type and have a normal capacity of 2000 kilowatts, although they can overload to a very large amount without danger for a period of several hours.

At the Fisk Street Station of the Chicago Edison Company shown in the accompanying illustration, Fig. 2, may be seen

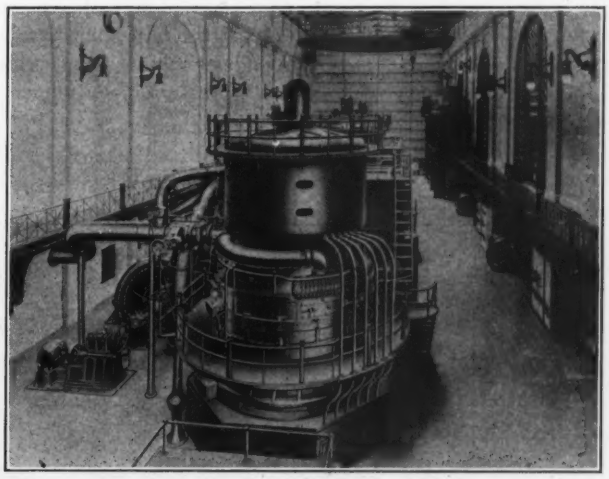


Fig. 2 - 5000 K.W. 9000 Volt Turbo-Alternator at the Fiske Street Station, Chicago Edison Co.

three Curtis vertical turbo-generators each having a capacity of 5000 kilowatts normal load with a maximum output of nearly 20,000 kilowatts for the three units, without injury

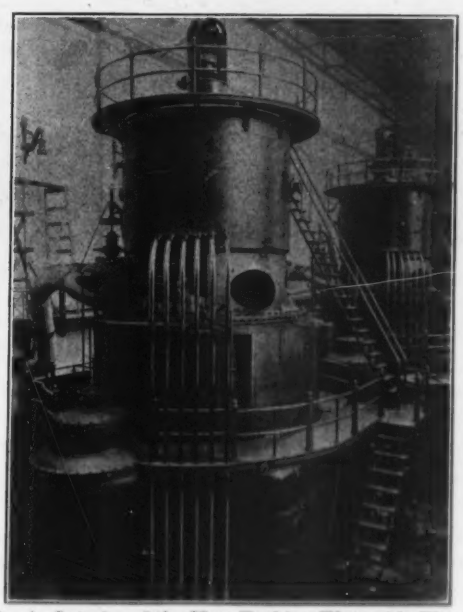


Fig. 4—Interior of the New Turbine Waterside Plant, New York City

for a considerable period of time. These machines operate at a speed of 500 revolutions per minute and deliver a three-phase alternating current of 9000 volts pressure, the frequency of the current being 25 cycles per second. These vertical

turbines are of the two-stage type, the alternators having six poles, with exciters and other auxiliary apparatus electrically driven.

At the Waterside Station of the New York Edison Company there are a number of vertical reciprocating engines in service with revolving field alternators of the slow speed type and also turbo-alternators of even larger output, yet occupying only a fraction of the space of the vertical reciprocating sets. The accompanying illustration, Fig. 3, is an excellent comparative view of a 5000 kilowatt Curtis turbo-alternator in the Waterside Station noted at the right and a 3500 kilowatt direct connected vertical compound engine set at the left. The turbine operates at a speed of 500 revolutions per minute and supplies a three-phase current of 6600 volts pressure, the frequency being 25 cycles per second.

The accompanying illustration, Fig. 4, shows two high-power vertical Curtis-turbo-alternators, these being the fifth and sixth units of this type installed in the Central Station shown. The old Waterside Station and the New Turbine Waterside plant have together a total contemplated capacity of a quarter of a million horse power. The old station has a capacity of 70,000 kilowatts and the new Waterside Station at the East River water front is designed for an output of 80,000 kilowatts, there being 10 vertical and horizontal steam turbo-alternators provided for of the Curtis and Westinghouse-Parsons types of 8000 kilowatts each, the latter operating at a speed of 750 revolutions per minute and supplying a three-phase current of 6600 volts and a frequency of 25 cycles per second.

The boiler plant supplying steam to these turbines includes 96 boilers of 6500 square feet of heating surface for each, connected to four stacks having an internal diameter of 20 feet at the top. These chimneys are 300 feet high and are constructed of steel, lined with one inch of concrete and four inches of common red brick, designed to be renewable in sections as found necessary.

There is a coal tower provided for unloading the fuel with a height of 172 feet and width of 25 feet and a length of 105 feet. After the coal is crushed it is hoisted to the top and distributed by 3-ton cable cars having a capacity of operation of about 360 tons per hour, the cars running around above the coal pockets in the boiler rooms. The steam is supplied at a pressure of 175 pounds per square inch to the steam turbines, with 100 degrees of superheat and a vacuum of about 28 inches.

The vertical turbines in the Waterside turbine station are about 15 feet in diameter at the base and are 32 feet high. These 8000 kilowatt units are guaranteed to develop 9000 kilowatts continuously for 24 hours and for two hours an overload of 50 per cent. without excessive heating, or a maximum output of 12,000 kilowatts.

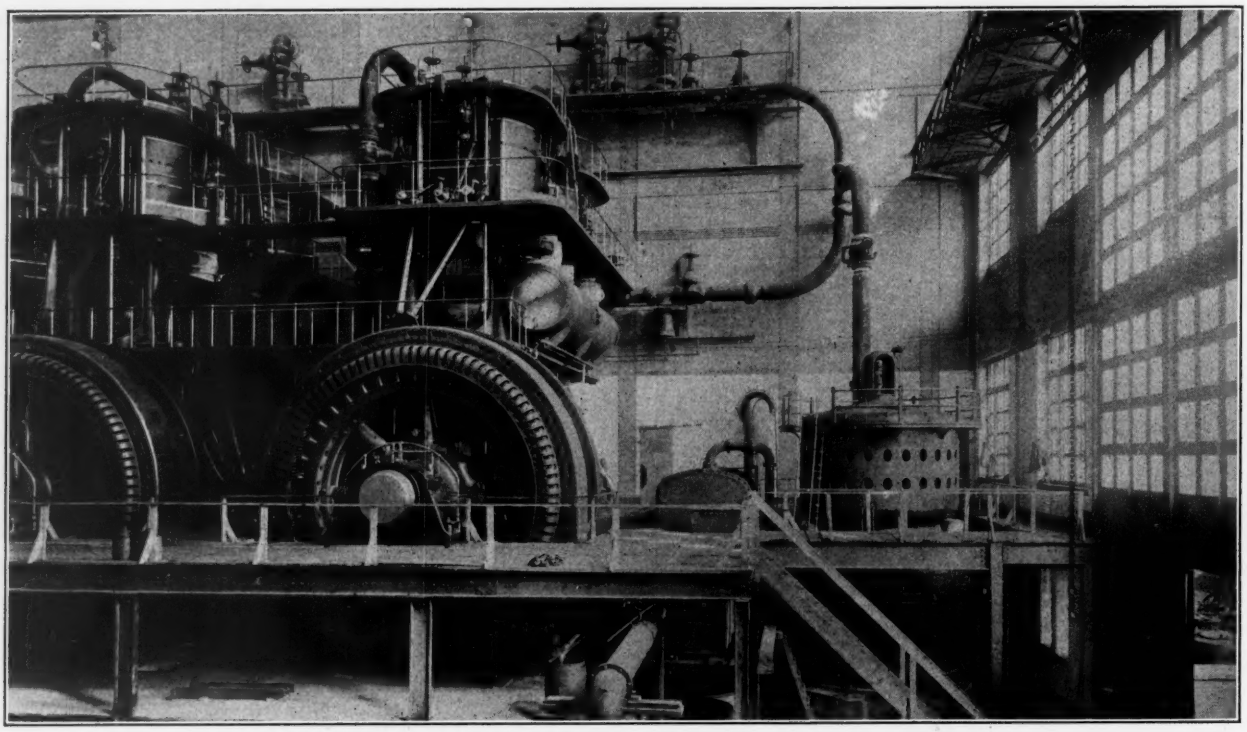


Fig. 3—5000 K. W. Turbo-Alternator and 3500 K. W. Vertical Compound Engines in the old Waterside Station, New York Edison Co., New York City

The Westinghouse-Parsons turbo-alternators are guaranteed to develop 50 per cent. over their rated load of 7500 kilowatts for three hours without danger, These horizontal turbo-alternators are 15 feet high, with a width of 17 feet and a total length of 50 feet over all.

At the central station of the Edison Illuminating Company of Boston, Mass., the vertical turbo-alternators are of 5000 kilowatts capacity and operate at a speed of 514 revolutions per minute, these units being of the four-stage type, with 14 pole alternators also supplying a three-phase current at 6600 volts pressure.

ARITHMETIC FOR ENGINEERS

Addition, Subtraction, Multiplication and Division of Decimal Fractions

By E. S. Hawkins.

PART V.

A curious trait in most men is the indifference with which they accept conditions, tools, methods or customs with which they are familiar, never questioning their origin or development. Trees do not grow in a day, neither did the science of mathematics, yet it is habitual to think of it as having always been here, whereas it has been built up through the laborious efforts of men of genius from ages immemorial. The use of decimals, for instance, was almost unknown before the early part of the eighteenth century, although it had been gradually developing since the addition to the numerical system of the cypher some time in the first centuries after Christ.

By recalling the effect of position on the value of integers, a clear conception of decimal fractions may readily be gained. It is remembered that only the figures in the first place to the right have simple value, and that the value of the others is governed by the place they occupy; thus, in 654, the 4 alone has simple value; 5, in the second place, means five tens or 50, and 6 in the hundreds place means 600. Each unit, then, indicates value ten times greater than would one placed on its immediate right, or, in other words, in counting from right to left the figures increase in value on a scale of ten. It is readily seen, therefore, that values may by this system be increased indefinitely, and, since this is true, its converse is also evidently true, as a number may be indefinitely lessened in the opposite direction.

For example, beginning with 10,000, divide it by 10 and the result is 1,000, which when also divided by 10 gives 100 as the quotient. Dividing this latter figure by the same quantity 10, the result is 10, and again performing the division the final result is 1 or unity. To descend still further from the unit of value we perform another division and get the decimal 0.1, which is called one-tenth, and when again divided by 10, gives the quotient 0.01, or one-hundredth. Another division gives the quantity 0.001, or one-thousandth, and the process may evidently be continued indefinitely. Remembering that *decem* is the Latin word for ten, we see from whence the system of decimals derives its name, as each decimal fraction has a denominator formed of 10 or one of its powers. This denominator, while not expressed, is readily found by putting in the decimal point's place and annexing as many cyphers as there are places pointed off in the given decimal fraction. Since this denominator is unexpressed, some plan must be adopted to distinguish decimals from integers, and this is done with the decimal point which is placed between units and tenths; thus the quantity 4.2 is read "four and two-tenths" and 6.5 is read "six and five-tenths," while 7.05 reads "seven and five-hundredths." In the next decimal place the decimal reads as so many thousandths and so on for tens of thousandths, hundreds of thousandths, millionths, etc.

In writing decimals, there will be no difficulty if a few simple instructions are regarded. It is easy to find the name of any decimal quantity, as all that is necessary is to regard the point as occupying unit's position in the decimal notation, when the name of each successive place to the right of the point will correspond to the similar names of integers placed in successive positions to the left of the integral unit position. Where there is no figure to occupy one or more of the positions in the decimal number the place must be filled by a cypher so that the position of the other figures in the given decimal number will not be changed with reference to the decimal point. Moving the point one place to the right multiplies the value of the decimal by 10 and, conversely, moving it one place to the left, divides the decimal number by the same quantity; thus 12.5 is divided by 10 by writing 1.25 and by 100 when written 0.125. This is read "one hundred and twenty-five thousandths" and the cypher may or may not be placed to the left of the decimal point. It has no significance in that position in so far as the value of the number is concerned, but it is well to set down to cypher because it aids the eye in adding up decimals since the figures can be written more regularly in their proper positions, and when one sees a cypher written he is reasonably sure that it was not intended to write a significant figure in that position. On the other hand, if the cyphers are not written and a significant figure should be omitted by accident, there would be no way of detecting the error. A decimal, then, may be multiplied or divided by simply changing the position of the point.

A common fraction is readily reducible to a decimal by taking the numerator for the dividend, placing after it a point and as many cyphers as necessary and, using the denominator as a divisor, performing the division. The quotient will be the value of the fraction expressed decimally. Given ¼ to be reduced to its equivalent in decimals, and the solution is $1.00 \div 4 = 0.25$.

Addition of Decimals.—Since we know that all figures to the right of the decimal point form a number representing a fractional part of a quantity or whole number, and all to the left form whole numbers, it is readily understood that in adding or subtracting decimals, the figures must be so placed that the decimal points will be under each other, without regard to the number of figures on the right of the decimal point. Add cyphers if desired to make the different numbers even up at the right-hand end, as this in no way affects the value of the quantities and aids the eye in following the columns, especially where there are several quantities to be added, all of which have a number of decimal places:

Addition.	*Subtraction.*
6.74389	7.4320
85.03700	4.5685
72.98431	
103.72562	2.8635
96.34753	
364.83835	

Multiplication of Decimals.—In multiplication we discard position relative to points and proceed as in integral quantities until the multiplicand is obtained when as many figures are

pointed off as there are decimal places in the two terms taken together. In counting the figures to be pointed off begin at the right and count to the left. As an example, 1.25×0.75 gives 0.9375, it being noted that four places are pointed off, this being the sum of the decimal places in the two quantities taken. The reason for this is plain when the quantities are considered as fractions with their denominators unexpressed.

$$\frac{125}{100} \times \frac{75}{100} = \frac{9375}{10000} = 0.9375$$

Division of Decimals.—This process is as simple multiplication if the decimal point is neglected until the divisions complete when its proper position in the quotient is found by pointing off as many places counting from the right as the decimal places in the dividend exceed those in the divisor. If the number of places in the divisor exceeds the number in the dividend, add cyphers to the right of the latter as necessary to perform the division. Recalling the fact that division is the opposite process to multiplication, it is not difficult to see why the difference between the number of places in the dividend and in the divisor is taken as the number of places to be pointed in the quotient. The process is not affected if the divisor is larger than the dividend, as cyphers may be added to the dividend. Example: $0.035800000 \div 0.652 = 0.054907$. Here it was necessary to add five cyphers in the dividend, and as this made its number of decimal places greater by six than those of the divisor, six places must be pointed off in the answer. Where the number of decimal places is the same in both dividend and divisor, no decimal point is used in the quotient, which is then a whole number. It is well in employing decimals to remember that there is no principle involved in using the point, it being merely a convenient and useful custom or system. In using decimals for ordinary work it will be found convenient where there is considerable figuring to make use of a table which shows the decimal equivalents of a number of common fractions in ordinary use.

DECIMAL EQUIVALENTS OF AN INCH.

8THS.				32DS.				64THS.			
1/8	.125	1/16	.5625	1/32	.53125	2/64	.140625	33/64	.578125		
2/8	.250	2/16	.6875	2/32	.59375	3/64	.171875	34/64	.609375		
3/8	.375	3/16	.8125	3/32	.65625	4/64	.203125	35/64	.640625		
4/8	.500	4/16	.9375	4/32	.71875	5/64	.234375	36/64	.671875		
5/8	.625			5/32	.78125	6/64	.265625	37/64	.703125		
6/8	.750	1/32	.03125	6/32	.84375	7/64	.296875	38/64	.734375		
7/8	.875	2/32	.09375	7/32	.90625	8/64	.328125	39/64	.765625		
16THS.		3/32	.15625	8/32	.96875	9/64	.359375	40/64	.796875		
1/16	.0625	4/32	.21875	64THS.		10/64	.390625	41/64	.828125		
2/16	.1875	5/32	.28125	1/64	.015625	11/64	.421875	42/64	.859375		
3/16	.3125	6/32	.34375	2/64	.046875	12/64	.453125	43/64	.890625		
4/16	.4375	7/32	.40625	3/64	.078125	13/64	.484375	44/64	.921875		
		8/32	.46875	4/64	.109375	14/64	.515625	45/64	.953125		
						15/64	.546875	46/64	.984375		

Cause and Effect of Various Points in Valve Setting

The "Old Man" gives some Valuable Information about Lap, Lead, Cut-off, Release and Compression

"Well, gentlemen, as I see no question on the desk, I take for granted that you have studied out the part of last evening's work which appeared in the February issue of THE PRACTICAL ENGINEER on the setting of piston valves. That may not have been exactly clear to you at the time, so on that assumption we will this evening consider the various causes and effects of those different points on the working of the engine.

"We will, therefore, begin at the point where we left off last evening, which was with the crank on the top centre, and the reversing-links in mid-gear, or with the valve in its central position; in which position the lap of the valve is always taken. As there is no standard rule or set of rules governing the various points of steam distribution in the cylinder, the consequence is that if there were two engines designed to indicate the same horse power, on the same consumption, and for the same class of work, but built by different builders, we would probably find them with different points of steam distribution altogether, as that is an item which is left entirely to the practice and judgment of the builder. So in considering the cause and effect of the various points this evening, the same will apply to steam engines in general. Lap, then, is the amount the valve overlaps the edge of the port either on the steam or exhaust side, and is known as steam lap or exhaust lap.

"Steam lap, being the amount the valve overlaps the steam edge of the port, with the valve in its central position, is given the valve so that it can cut off the supply of steam to the cylinder before the stroke is completed, the stroke being completed by the expansive force of the steam only. Steam lap also affects all the other points of steam distribution, owing to the relation between the steam lap of the valve and the position of the eccentric sheave, or what we call the angle of advance.

"Exhaust lap is the amount the valve overlaps the exhaust edge of the port, and is given to a valve to close the exhaust port for compression earlier, and open the exhaust port for release later, than those points would be when caused by the angular advance of the eccentric only, and is generally given to engines of low piston speeds which have valves of short travel.

"Now besides having steam and exhaust lap, which are positive, we also have what is known as 'Negative or Minus' lap on the exhaust side of the valve, which is the amount the valve comes short of the edge of the exhaust port when the valve is in the central position, and is given a valve to cause the opposite effect of that which is caused by the 'exhaust lap,' or to close the exhaust port later for compression and open the exhaust port earlier for release, than those points would be when caused by the angular advance, and is generally given to engines which have high piston speed. If you refer to the article on piston valves you will find that valve has 3/8" on top and 1/4" bottom—negative lap. Now I wish to draw your particular attention to this point of 'Negative Lap,' the effect of which is seldom recognized by the young engineer, when shown on the indicator card. Where you have a valve which has negative lap, you will always find a sudden rise at a certain point on the back pressure or exhaust lines of the indicator card taken off that cylinder, which rise is often attributed to any

and every cause but the right one; now the cause of this rise in the exhaust line of the card is, that at a certain point in each stroke, or twice in one revolution, the both sides of the piston are in communication with each other, owing to the top and bottom exhaust ports being open to exhaust at the same instant. This you can see in Fig. 3 of article in February issue, where the top exhaust port is just open to release and the bottom exhaust port has not yet closed for compression, and vice versa in Fig. 7. The consequence is, that the pressure of the steam being greater on the top of the piston than on the bottom, when the valve opens the top port for release, the steam rushes out and down through the bottom port and in under the piston before the valve closes the bottom exhaust port for compression, and so causes the rise in the line for back pressure. Now that we have seen what the lap in the valve is and how it is measured, the next point we will take up is the lead of the valve, which was shown in Figs. 1 and 5 of the February article, to be the amount the steam port is open to admit steam to the cylinder when the crank is on the centres and links in *full gear.*

"Lead, then, is caused by the angle of advance of the eccentric, and as the angular advance affects all points directly or indirectly, it is necessary to understand what it actually is. So to illustrate angular advance we will take, for instance, an engine that carries the steam the full length of the stroke; for such an engine the position of the eccentric in relation to the crank would be exactly 90°, or at right angles either leading or following the crank, according to the design of the valve. If it is a slide valve or piston valve, which admits steam to the cylinder over the ends of the valves, the eccentric would lead or be in advance of the crank as in Fig. 10, but if it happened to be a piston valve which admits steam to the cylinder from the middle of the valve or between the ports, then the eccentric would follow or be behind the crank exactly 90°, as in Fig. 11. Now such an engine would have no angle of advance of the eccentric, but directly we use steam expansively or cut-off steam before the stroke is completed we must put lap on the valve to get that cut-off, and after having added lap to the valve, it is evident that the valve would not open the port to admit steam of the cylinder early enough, therefore we would have to advance the eccentric the same amount as we have added to the valve, and then, after that had been done, we would find that the engine would be disposed to stop when it came to the 'dead centres;' so to remedy this we would have to advance the eccentric the same amount, and then advance the eccentric another ¼" for the 'lead.' The angular advance would be, as shown in Figs. 12 or 13 according to the design of the valve; and although the only change we have made in the valve itself is adding extra steam lap, yet if we took the setting of that valve, we would find that all the points had been changed, not by adding lap, but by advancing the eccentric, which proves that the angular advance of the eccentric affects all the points of steam distribution.

"Lead has nothing to do with the dimensions of the valve, but is caused by the angular advance of the eccentric, and is not given an engine to assist the compression in bringing the moving parts to rest, but rather to insure the necessary opening for the supply of steam to the cylinder when the crank reaches the 'dead centre.'

"Many text books are misleading to the student, one of which is especially recommended to marine engineers and endorsed by a section of the Marine Engineers' Beneficial Association and also by a prominent consulting engineer, so I will quote what this author has to say on the subject which we are considering this evening. According to this author:

" 'Leads are of two kinds, outside or steam lead, and inside or exhaust lead. Outside or steam lead is the distance that the outside or steam side edge of the valve comes short of covering the port when the piston is at the beginning of the stroke. Inside or exhaust lead is the distance that the inside or exhaust side edge of the valve comes short of covering the port when the piston is at the beginning of the stroke.'

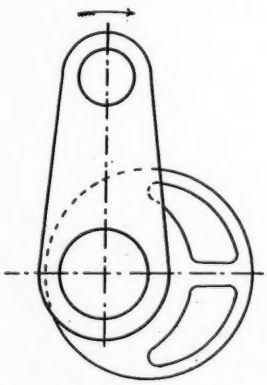


Fig. 10

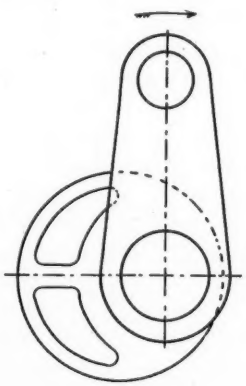


Fig. 11

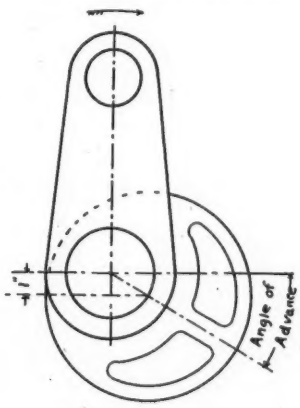


Fig. 12

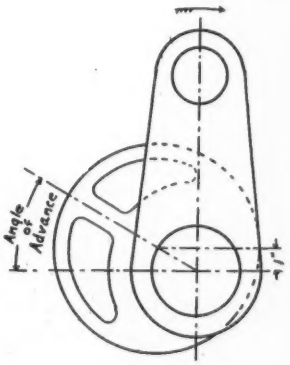


Fig. 13

"This author also states that 'Leads accelerate or increase the speed of the valve gear and engine, and is generally given to high speed engines.' The first misleading statement is 'Leads are of two kinds.' Now, as a matter of fact there is only one kind of lead which is steam lead, and that, as we have already seen, may be either outside or inside, according to the design of the valve, it is measured with *the piston at the beginning of the stroke* and the reversing links in full gear. By the inside or exhaust lead this author evidently means 'negative lap,' which is 'the distance the inside or exhaust side edge of the valve comes short of covering the port when the piston is at the beginning of the stroke,' but with the reversing link in *mid-gear,* or with the valve in its central position. By neglecting such a simple thing as to mention the position of the valve or links, this author leads the student a long way out of his course, as you see by referring to Fig. 1, page 24, February

issue, where the links are in full gear and 'the distance the exhaust side edge of the valve comes short of covering the port' is exactly 3⅛" at the bottom, or the bottom exhaust port is nearly full open, while the top exhaust port has 2½" lap, which, I would point out to you, would be exactly the same with an engine which had no reversing gear, the bottom exhaust port would be nearly full open and the top exhaust port would have a positive lap, because it is not possible to measure the lap of such an engine with the 'piston at the beginning of the stroke,' for the valve must be in its central position when measured.

"The author's further statement that 'Lead accelerates or increases the speed of the valve gear and engine and is generally given to high speed engines' requires no comment from me, further than I consider it as misleading as his statement of 'exhaust lead.' The next point we come to is one which will require a little explanation from me, namely, the point of cut-off, which is the point where the supply of steam to the cylinder is cut off by the valve, causing the piston to complete the stroke by the expansive force of the steam only, and as we have already seen, this is caused by the lap of the valve. It is to improve this point more than any other in steam distribution that our eminent engineers expend both money and brain inventing and patenting valve gears, the whole object of which is to get a full port opening with a sharp or quick point of cut-off; one of the greatest objections to the ordinary link motion being the slow opening and closing of the steam port, as in both operations the steam is more or less 'wire drawn,' the result of which is anything but conducive to high efficiency or economy in the engine.

"The point of release is the point where the valve opens the exhaust port to release the steam from the cylinder, when the steam has expended a certain amount of energy in doing work in that cylinder and is governed partly by the angular advance, and partly by the exhaust lap (either positive or negative) of the valve. A valve having positive lap will evidently open the port later for release than the valve with negative lap, assuming both valves to have the same travel and angle of advance, therefore the designer can counteract the effect of the angular advance by positive lap on the exhaust edge of the valve, or he can assist or increase the effect of the angular advance by giving the valve negative lap on the exhaust edge; such assistance or counteraction being governed by what is known in the designing of an engine as "the velocity of flow of exhaust,' which give engines of high piston speed much earlier points of release than engines of low piston speed.

"The last point is comparison, where the exhaust port is closed by the valve before the piston has completed the entire stroke, the effect of this being that the steam which was in the cylinder when the port closed is compressed and so raised in pressure, which pressure increasing and resisting the piston as it completes the stroke that the momentum of the moving parts is brought gradually to rest, without excessive jars and stresses coming on those parts when the line of motion is changed, or when the crank has turned the centre.

"You will find stated in many standard textbooks that 'Compression depends upon steap lap;' now this statement has given many young engineers wrong ideas, for they infer from that if they increase the steam lap the point of compression is increased also; which is where they make the mistake, for increasing the steam lap would only affect the compression if the eccentric was altered at the same time, or if they increase the angle of advance of the eccentric, so the statement that 'Compression depends on steam lap' simply refers to the relation between the steam lap of the valve and the angle of advance of the eccentric, which the steam lap controls. Compression, like release, is also affected by the exhaust lap of the valve, or can be increased by the positive lap on the exhaust side and decreased by the negative lap of the valve.

"Now, gentlemen, as we have taken the various points in their rotation, I wish to point out that in the explanation which I have given you I am not attempting to expound any new theory or idea on those points, although it may appear so to those among you who have already got certain ideas regarding those points, but my explanations are given in the hopes that they may assist you to better understand what your textbooks have to say on this subject, as many of our textbooks take for granted that the young engineer is more advanced in his knowledge of this subject than is actually the case."

———o———

New Way of Making Phosphorus.

Until recently, phosphorus, which is used chiefly in the manufacture of matches, was made solely from bones and organic substances. There is something gruesome in the thought that illumination should have come to us by way of death, but the fact remains that only since the perfection of the electric furnace have natural phosphates been used to any extent in making phosphorus, says the latest United States *Geological Survey Bulletin.*

At the foot of the northern slope of South Mountain, in the vicinity of Mount Holly Springs, Pa., about ten miles southwest of Harrisburg, a deposit of wavellite occurs in the white clay associated with manganese and iron ores. Small quantities of phosphorus had previously been obtained from phosphorite and from apatite, but wavellite, which is aluminum phosphate, has never before been used commercially in the manufacture of phosphorus, as the mineral generally occurs in very limited quantities.

The clay in this region is extensively mined as a filler for wall paper in the vicinity of Mount Holly Springs, and prospected for everywhere along the mountain front. It was in one of these prospect pits that peculiar round white nodules were found in the clay. The less weathered of these when broken open show a beautiful, radiate, silky, fibrous structure. It proved to be wavellite, a rather uncommon mineral in so pure a form, and not known to occur elsewhere in sufficient quantity to be mined.

Of the different methods of manufacturing phosphorus, the Readman process, patented in 1889, is the one that has come into commercial use in most countries.

The world's production of phosphorus has been variously estimated to be from 1000 to 3000 tons a year. The greater part is made in the Albright & Wilson factory. Wednesfield (Oldbury), England, where the Readman process originated. Other large factories are located at Lyons, France, and at Griesheim and Frankfort, Germany. There is also a plant in Sweden, and there are numerous smaller ones in Russia.

The census of 1900 in the United States reported three phosphorus establishments in operation, but the census of 1904-05 reported only one, at Niagara Falls.

PRACTICAL HINTS ABOUT THE INDICATOR

Methods of Reading and Taking Cards

By Wm. Kavanaugh.

If the theory of the expansion of gases is understood, every engineer will be in a position to comprehend the action of steam in the cylinder of an engine after it is cut off. In order to have this knowledge, Boyle's or Marriott's law, relating to the expansion of gases, must be understood. This law reads as follows: When the temperature remains constant, the volume of a gas varies inversely as the pressure upon it. In other words, the product of the volume of a gas times its pressure is constant.

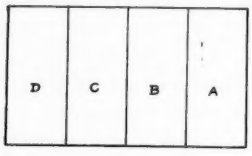


Fig. 1

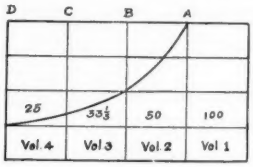


Fig. 2

This law can be illustrated in a simple manner by supposing that a vessel of known volume is filled with gas and the pressure 100 pounds per square inch. If the volume of the vessel be doubled, the pressure of the gas will fall to 50 pounds per square inch. Suppose Fig. 1 to be the cylinder divided into four equal parts, A, B, C, D, and suppose volume A is filled with steam at 100 pounds pressure. If now the steam valve closes and the piston is free to move toward D, then when the piston is at B the pressure will have fallen to 50 pounds when at C to $33^1/_3$ pounds and when it has arrived at D, the pressure will be 25 pounds.

Suppose a cylinder is 16 inches diameter and 32 inches long and divide it into four equal parts as shown in Fig. 2. Now admit steam of 100 pounds pressure and let the valves close when the piston is at A. Then the piston travelling through the various volumes will arrive at D with a pressure of 25 pounds per square inch. If the line AE be drawn so as to cut the various volumes at the different pressures, it will terminate at E on line D. The line AE is called the expansion line and curve which it forms is called the expansion curve. In actual practice this exact curve is never obtained, since the steam loses or parts with its heat during expansion.

Having given due consideration to the theory of the expansion of gases, the study of the indicator card can be begun.

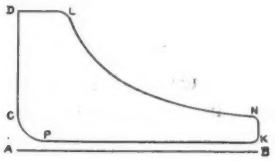


Fig. 3

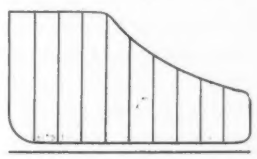


Fig. 4

Referring to Fig. 3, AB is called the atmospheric line because it is drawn when there is no steam pressure permitted to act on the indicator piston. CD is called the admission line because it represents the opening of the steam port for the admission of steam to the cylinder. DL is called the steam line and the length of this line shows how long the steam port remained open for the admission of steam to the cylinder. The point shown at L is called the point of cut-off, and in an automatic cut-off engine this point varies as the load varies; in other words, the point of cut-off is variable. The curve LMN is called the expansion curve and it shows how closely the theoretical expansion curve was followed by the curve of the expanding steam. The expanding steam continues to push or move the piston with a decreasing pressure until the piston arrives at the point N, when the exhaust valve opens the exhaust port and the steam escapes either into the atmosphere or into a vacuum. The curve NK is called the exhaust curve and it shows the point at which the exhaust port was opened for the rejection of the expanded

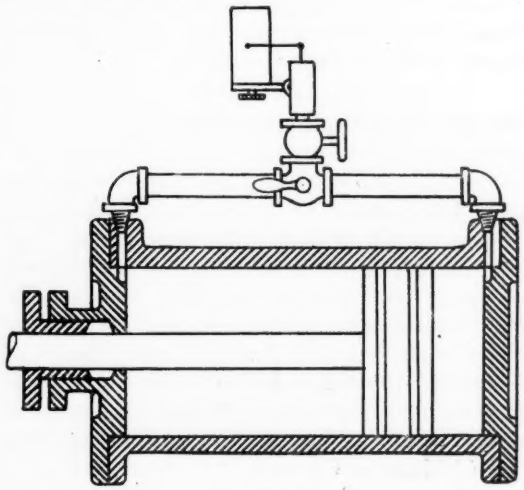


Fig. 5

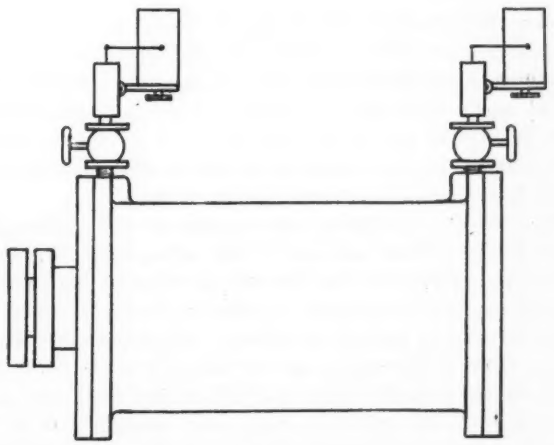


Fig. 6

steam. The line KP shows how long the exhaust port remained opened and the point P shows the point in the stroke of the engine or piston travel where the exhaust valve closed the exhaust port.

When the exhaust valve closes the port, a certain amount of steam, which would otherwise have escaped, is retained in the cylinder, which acts as a cushion and serves to gradually retard the motion of the piston and bring it to rest. The piston in travelling from P to C compresses whatever steam the exhaust valve has shut in the cylinder and the act of compression raises the pressure the amount indicated by the dotted line AC; for this reason the curve CP is called the compression curve. The moment the pressure of the compressed steam reaches the point C, the steam valve begins to open the port and admit a fresh supply to drive the piston once again on its next stroke.

The distance between the lines AB and PK indicates the amount of back pressure that the exhaust steam exerts on the piston in passing out of the cylinder, and the further apart these lines are, the greater will be the back pressure on the engine, and the less its economy, other things being equal.

A good indicator card should conform to the following requirements: First, the back pressure line PK, Fig. 3, should be parallel with the atmospheric line and the distance between those two lines should not be over one or two pounds pressure if the engine is non-condensing; secondly, the admission line CD should be perpendicular to the back pressure line; thirdly, the steam line DL should be parallel with the back

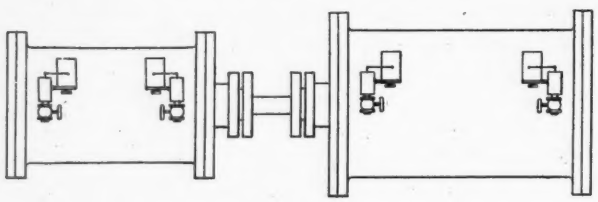


Fig. 7

pressure line; fourthly, the point of cut-off at L should be sharp and well defined; fifthly, the expansion curve should approximate the theoretical curve; sixthly, the exhaust curve should have a quick drop; seventhly, compression should begin about 11/12 of the stroke; that is, with an engine having a six-inch crank, the exhaust port should be closed when the piston has completed 11 inches of its stroke.

The indicator card being a photograph of the action of the steam in the cylinder and also of the movement of the steam and exhaust valves for the different positions of the piston, it follows that any irregularity in their movements can be obtained by reading the indicator card. This knowledge enables one to learn if the valves are set correctly so as to produce the most economical results, and also to find the horse power developed by the engine at any given moment. From the indicator card, the average pressure under which the engine is operated at any given time can be obtained.

In order to obtain the horse power from an indicator card, the card may be placed on the drawing board or other level surface, and with a planimeter the area of the card can be traced; then divide the area so found by the length of card and multiply the quotient by the scale of the spring. The product will equal the average pressure throughout the stroke. One of the factors has now been found for determining the horse power of the engine. The next thing to find out is how many feet the piston travels in one minute. Having found this, the area of the piston in square inches must be calculated. The three necessary factors for determining the horse power of the engine are thus obtained. To find the horse power, multiply the area of the piston by the number of feet the piston travels in one minute and by the average pressure, and divide the product by 33,000; the quotient will be the indicated horse power.

When a planimeter is not at hand, with which to trace the area of the card, the average pressure can be obtained by erecting ordinates equi-distant on the card, as shown in Fig. 4, and measuring each ordinate by the scale of the spring. If these ordinates are added together and the sum divided by the number of ordinates, the result will be the average pressure.

Indicators are fitted with a number of springs to correspond with the various pressures under which different engines operate, some engines receiving an initial pressure of 200 pounds, while others receive only 40 or 50 pounds. In order to find the spring for any pressure, divide the initial pressure by 2 and the quotient will equal the required spring.

A spring scale is a rule or scale graduated by the inch to suit the spring. If the spring is 30, then each inch of the scale will be divided into 30 parts, and so on for any number of spring, the number being stamped on the spring.

Different methods of applying the indicator are shown in the accompanying illustrations. Fig. 5 shows the application of one indicator to an engine cylinder when a three-way cock is used. Fig. 6 shows the method of applying two indicators to the one cylinder. It will be noticed that with this method cards can be taken without losing time in opening and closing the three-way cock, and it insures greater accuracy than is possible with a single indicator. The application of four indicators to a tandem compound engine is shown in Fig. 7. In order to obtain precise information about the simultaneous action of the valves, this method is necessary.

———o———

What a Well-Pleased Subscriber Says.

EDITOR THE PRACTICAL ENGINEER:

Enclosed you will find my renewal, and I desire to say that I like the paper better than ever. In every issue I can always find some interesting article which the most casual reader cannot fail to read over again if he is truly wishing to study and improve himself; for instance, Setting Piston Valves, in August; The Economical Distribution of Steam, in September; Reversing Shaft Governor Engines, in October; Care and Management of Horizontal Tubular Boilers, in November; Some Working Tools of an Engineer, in December; Boiler Explosion at Lynn, Mass., in January; Setting Piston Valves by the Old Man, in February.

These are all interesting and instructive lessons, and I would like to see the article on Engineers' Working Tools continued. There are other lessons in the paper all the way through which show the ability of the writers to handle the subjects treated. You can still count on me remaining a friend and reader of THE PRACTICAL ENGINEER. Wishing you continued success, JAMES WHITE.

Taylor, Wash.

PARALLEL OPERATION OF ALTERNATORS

By S. A. Fletcher.

The parallel operation of alternators and the division of current between them presents a problem which is not generally understood by men familiar with the simpler operation of direct-current generators. It is such a common thing to-day to run alternators in parallel that a few fundamentals on the proper division of load may prove of interest.

Nearly all modern alternators are not compound wound, but are separately excited from some independent direct-current generator. For this reason no equalizer is required, and the operation somewhat resembles that of direct-current shunt generators. With these latter generators, the load is readily divided according to capacity by a simple adjustment of the shunt fields. In the case of alternators, this method is only partially successful and must not be depended upon as the only means for regulating the load.

The reason the field control is insufficient is because of the alternating current. It would be possible to increase the field of one generator and decrease the other to such a point that the currents shown by the machine ammeters were practically the same and *yet have one alternator, a generator, and the other a motor and never know it.* As the ammeters cannot show a reversed current, each meter would deflect as usual. Such a situation is, of course, highly unsatisfactory, but by no means as uncommon as it should be. It can be detected in this way: The total current ammeter would show a current far less than the sum of the machine currents.

Such a case as the above is not possible with direct currents, as it would be detected at once. Not only would one ammeter reverse, but the motor would spark viciously, and the load on the generator would be considerably larger than the total load shown on the total current ammeter.

It is perfectly possible to prevent such a situation by correct handling of the alternators. The fundamental point is as follows: The proper division of load should be made almost entirely by adjustment of the governors controlling the speeds of the driving engines. This does not mean that the two alternators are not to have the same frequency, for this is absolutely essential; but does mean that an adjustment of the governors can be made after the generators are paralleled and still keep them in step and cause them to divide the load correctly.

Suppose, then, a second alternator is to be paralleled to share the load with one which has been loaded up to its limit. It must be phased in by using some suitable synchronizing device. This will require equality of voltage on the two. As soon as No. 2 is thrown in it will take some current, but we have no ready means of telling whether it is a motor or a generator. The field rheostat should not be touched, but the governor on No. 2 should be adjusted for a very slight increase of speed. This will overcome any tendency of No. 2 to be a motor and cause it to run as a generator and begin to take its load. The governor should continue to be adjusted on No. 2 until the currents on the two machine ammeters are practically in proportion to the kilowatt capacities. Then the readings of the two machine ammeters should be added together and compared with, and together should equal, the total ammeter reading. It is probable that the total ammeters will show less than the sum of the two machine currents. Now is the time for a very slight adjustment of the fields. Probably No. 2 should have its field strengthened a trifle. If this is found to improve the situation, it should be continued, together with an adjustment of the governor on No. 2, until finally the loads are divided in the correct proportion and, equally important, the sum of the two machine currents is equal to the total current on the line.

This last point is one very little noticed by station operators. If the total current ammeter shows a current less than the sum of the machine ammeters, it indicates that the currents delivered by the two generators are not exactly in phase with each other. This represents a direct waste, for more current is being delivered by the generator than is being used in the load. Such a condition would not be possible with direct currents, because when currents are added together their arithmetical sum must be the current resulting. In alternating currents it is seldom the case that the addition of two currents will produce a single resulting current equal in value to their arithmetical sum. This is due to the fact that the currents are alternating in direction of flow very rapidly, and hence constantly changing in value from instant to instant. If these changes in the two currents do not occur simultaneously the currents are said to be out of phase, and their sum will be less than the arithmetical sum, because of this difference in their times of changing. An ammeter connected in the circuit will show a steady reading, as it in a way averages all these values and shows it on the meter. For a concrete case, suppose we have two currents of 10 amperes each flowing in separate circuits, and we cause them to unite and flow in the same wire. If they are out of phase, we will obtain less than $10 + 10 = 20$ amperes and may have perhaps 18. This evidently represents a loss of two amperes. It is caused by the difference in phase.

To take a concrete example, let us consider two three-phase alternators of 500 kilowatts each. These are rated at 4100 volts, which gives a full load current of $C = \frac{500 \times 1000}{4100 \times 1.732} = 70.4$ amperes. Machine No. 1 is run alone until the load increases to 80 amperes, when machine No. 2 is started and phased in. Its ammeter shows at first 10 amperes. The governor of No. 2 is now adjusted to increase the speed slightly. This causes the reading of ammeter No. 2 to increase and No. 1 to decrease. This is correct. The adjustment is continued until both ammeters read nearly alike. Suppose this gives No. 1 50 amperes and No. 2 48, while the total ammeter shows but 80, as before. Evidently the two generators are generating too much current. These figures are perfectly possible, as the currents are not exactly in phase. Hence, something must be done to bring them into phase. This is done by adjustment of the fields. We find by increasing the field of No. 2 that both currents decrease, but No. 2 faster than No. 1. Therefore, the governor of No. 2 should be adjusted for a slight increase as before and the field regulated, until finally the

two ammeters show 40 amperes each and the total, as before, 80 amperes. This now is the correct adjustment for equal sharing of the load. It would be absolutely impossible to obtain this without an adjustment of the governors. In fact, it must be realized that the speed adjustment is of far more importance than field adjustment. It must be noticed that the actual speeds are not changed by adjustments of the governors after the alternators are once in parallel. But the tendency is to make the alternator try to run faster and hence makes it take more load, as more power is supplied to the driving engine and must be used in causing its generator to take more load.

To show that one alternator may run as a motor, the following case is cited, which is one of several that have come under the writer's experience: A large mill in one of the Southern States was electrically equipped throughout and originally supplied its own power from a three-phase 300-kilowatt alternator. But later the load became too large for the generator and a nearby hydraulic plant made such low terms on the power that a transmission line was put in from the plant to the mill and supplied the entire load. This was very satisfactory until the water was low at the dam of the power company. It was decided to help out the power house by paralleling the 300-kilowatt generator at the mill and make it carry as much of the mill load as possible.

No difficulty was found in phasing the generator in with the transmission line. They went together without demonstration of any sort and everything seemed exactly right. The operator then adjusted his field resistance at the mill until his ammeter showed full load current from his 300-kilowatt unit. He felt everything was satisfactory and allowed the set to run all day without further attention. But when the wattmeter readings were taken for that day the surprise of the attendant was great. Instead of being considerably smaller than usual, it was decidedly larger. The average figures for a day's load had been about 14,000 kilowatt hours, but this day the wattmeters from the power house showed about 20,000 kilowatt-hours. The load ran for about 20 hours. As the alternator at the mill was about 300 kilowatts, this increase of 6,000 kilowatt-hours was clearly caused by the alternator. It ran then *as a synchronous motor and took power from the power house, and instead of improving conditions made them worse.* It would have been perfectly possible to run this alternator correctly and have it help carry the load to the extent of $20 \times 300 = 6000$ kilowatt-hours. This would have brought the load to but 8000 kilowatt-hours from the transmission line, and naturally helped the situation if the attendant had made the simple adjustment of his governor on the steam engine driving the alternator. Other cases could be cited showing as well that lack of a clear understanding of this point may cause an attendant to allow a station to run under very poor conditions, when there is no necessity for them at all.

—o—

Cost of Electricity Obtained from Water, Steam, Gas and Oil.

At a meeting of the New York section of the American Electrochemical Society, held on February 26, Professor Charles E. Lucke presented a paper discussing in detail the various factors which enter into the cost item of the energy consumed in electrochemical industries. The author discussed the electric generating station, in which the source of power is water, oil, steam or gas. In each case commercial sizes of machines were chosen. The oil engine driven station was assumed to contain six 160-kw. units, four of which were to be in use constantly, the other two being held as reserve. In the gas engine driven station it was assumed that six 600-kw. units were installed, two of which were held as reserve. The steam station was assumed to contain six 500-kw. units, four being in use constantly. In the water-power station the units installed were assumed to be operated continuously at full load. The initial cost of the installation was found to vary from $75 to $200 per kw. for the water station, and from $110 to $150 per kw. for the steam station, for either reciprocating engines or steam turbines; while the equipment in the oil engine driven station were estimated to cost $217 per kw., and that in the gas engine driven station $270 per kw. In each case it was further assumed that the total investment cost per year per kilowatt could be taken at 10 per cent. The operating cost was estimated from values found to exist in practice. On the basis of the above assumptions the author presented the following table showing the cost of electrical energy obtained from the various sources, the values being in dollars:

	Water		Oil.	Steam		Gas.
	Min.	Max.	Mean.	Min.	Max.	Mean.
Initial cost per kw.....	75.	200.	217.	110.	150.	270.
Investment cost per year per kw.	7.5	20.	21.70	16.5	22.5	27.0
Operating cost per kw-yr....	1.	5.	56.9	52.5	52.5	38.5
Total cost of energy per kw.yr.	8.5	25.	78.6	69.	75.	65.5

In discussing Professor Lucke's paper, Mr. H. G. Stott called attention to the fact that the actual proportion of operating charges to fixed charges will vary largely with the load factor of the station. Thus with a 50 per cent. load factor, such as is common in railway service, the operating expense would be 61 per cent., the fixed expense 33 per cent., and other expenses 6 per cent., while with a 20 per cent. load factor, such as is common in lighting equipments, the operating expense would be 30 per cent., the fixed expense 60 per cent., and the other expenses 10 per cent. It is seen, therefore, that in comparing various stations it is extremely important to consider the load factor. Moreover, it is not proper to assume that the cost of operating steam turbines is the same as that for reciprocating engines. As a matter of fact, while three men are required for each 5,000-kw. engine unit, one man can care for two 5,000-kw. turbine units. The maintenance charge of a turbine will be perhaps one-fifth of that for an equivalent reciprocating engine. The load characteristics of a steam turbine are quite different from those of a reciprocating engine. On account of the leakage past the blades the turbine has a lower efficiency at light load than has the engine, but it can carry enormous overloads with a very much higher efficiency than can the engine.

Mr. F. G. Clark, in discussing the variation of cost of energy with the load factor of the station, remarked that while with a load factor of 100 per cent. the cost would be $35 per kw.-year, at a 40 per cent. load factor the cost would be $65 per kw.-year, and at a 20 per cent. load factor the cost would increase to $100 per kw.-year. He drew attention to the fact that in comparing gas and oil engines with steam engines one should not neglect to consider that steam engines and steam turbines can carry enormous overloads, while gas engines and oil engines are limited to about 25 per cent. overload. There-

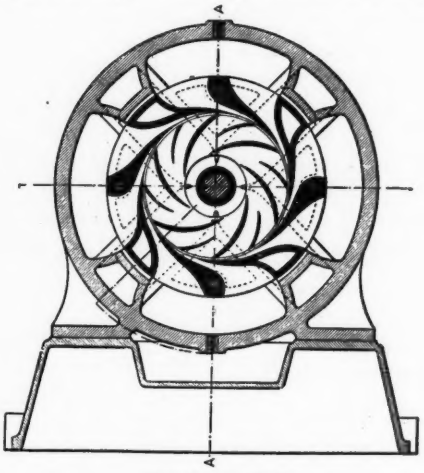
fore, it is not necessary to carry as much excess capacity in a steam equipment for peak loads as would be true with either a gas or an oil equipment. In the case of steam equipments it is possible to use water heat storage for equalizing the load on the boilers. Thus, immediately preceding the peak load it is possible to have the boilers filled with water at a high temperature and to shut down the feed pumps while the peak load continues, and depend on utilizing the energy stored in the heated water for the excess capacity demanded during the peak.

—o—

Centrifugal Pumps.

Probably the best way to consider centrifugal pumps is to compare them with reciprocating pumps. In the centrifugal pump there is no shock or water hammer because the liquid is always in motion and the flow is unceasing, no air-chamber being required to provide smooth operation.

In the first place the efficiency of the centrifugal pump is very nearly equal to that of the reciprocating type, and especially so when the centrifugal type is direct connected to either an engine or a motor. Durability of the centrifugal is another feature, for the efficiency after ten years of service of the reciprocating pump, if we consider an equal expenditure of repairs being made on each machine, would be very low, whereas the efficiency of a centrifugal pump would be maintained because the only wearing parts are the bearings, which



Section Through Centrifugal Pump

are lubricated with oil-rings and require very infrequent replacement. Compare this with the wearing out of the water-cylinder linings of the reciprocating pump. The third most important item is the oil bill. While reciprocating pumps demand cylinder lubrication, there is no corresponding expense connected with the operation of centrifugal pumps. Added to this is the advantage of the centrifugal pump in that it may handle gritty or acid liquids, and as it has no valves it may also handle water containing pulp or slime. The speed of the centrifugal pump is so high that it may be direct connected to motor or engine, whereas the reciprocating pump must be geared either through one or two speed combinations, with the attendant loss of power and resulting noise. Due to their higher speed the centrifugal pump also occupies less space for a given capacity, and particularly in mine work this is a great feature.

Centrifugal pumps may be divided into the two distinct types, namely, the volute type and the turbine type. While the volute type is more essential for lower heads, and where maximum efficiency is not absolutely necessary, the second, or turbine type, is used where high heads and maximum efficiency are required. In general, we may say that the turbine pump will require about ten per cent. less horse power for a given head and water quantity than the volute pump under the same conditions, and while either type of pump may be built to compound two or more stages, it is almost universal practice to use only the turbine type for compound units, for aside from a somewhat higher efficiency result, it lends itself more readily to a compact mechanical arrangement. All types of centrifugal pumps consist of two essential elements—first, the rotating impeller which receives the water entering at the inlet; and second, a stationary water-way contained in the outer shell, which receives the water thrown from the edge of the impeller. In the design of these two elements rests the secret of the success of the pump and the percentage of efficiency obtained. If the water were received from the inlet directly into the impeller without its course being changed by following a curve of the proper proportions, a large loss of power would result; secondly, if the water were discharged from the impeller directly into a large chamber, the efficiency of the pump would be very low, as the kinetic energy, or velocity of the water, would be entirely lost. The greater portion of this kinetic energy, or velocity, is used by directing the water into a throat and volute, or a diffusion ring. The throat, or diffusion ring, is merely an expanding water-way which allows the velocity of the water to be decreased gradually.

The proper proportion of the throat and the correct curve for the vanes in the diffusion rings are the result of many tests covering several years. It may be stated without exception that the general form of the volute, or passage-way in which the water finally finds its way to the outlet of the pump, is that of an Archimedes spiral, that is, the cross section increases in an arithmetic ratio up to the full area of the pump discharge.

To further draw a comparison between reciprocating direct-acting and centrifugal pumps, we may note the three chief variables, viz.: head, volume and speed. Given any constant head, the volume and speed are proportional, though not a simple function. A direct-acting pump, however, has a capacity or volume proportional directly to the number of revolutions. For any constant volume the speed required to operate the pump is a function of the square root of the head, while if we consider the speed constant, and note the effect of changing volume and speed, we shall find that their relations, though similar to that occurring with constant head, differ in that a greater change takes place in the volume for a change of head, and also that the variations are in the opposite direction. This will be readily appreciated when it is remembered that the water horse power must be approximately constant.

If the water be gritty or contain solid matter of any nature, we cannot select the usual speed, owing to the excessive wear which would result if the pump were running at as high a speed as with clear water. This is one of the most important considerations—limiting the speed of the pump—and is the factor which governs the capacity of dredging pumps. One way of providing for a lower rotation speed is to build the pump in two, three or more stages—thus dividing the R. P. M. by 2, 3, 4, etc. Though up to this time no pumps in this country have been constructed containing more than eight stages, it seems entirely feasible to build them with more.

The
Practical Engineer

DEVOTED TO THE ECONOMICAL GENERATION AND UTILIZATION OF POWER

PUBLISHED ON THE FIRST OF EACH MONTH BY

L. L. RICE

46 North Twelfth Street Philadelphia, Pa.

Correspondence solicited, and paid for upon publication. Short articles descriptive of the small problems met with in daily engineering practice are especially desirable. Illustrations prepared from pencil sketch.

Subscription Price, Fifty Cents a Year in advance to any Post Office, in the United States, Canada, Mexico or United States Possessions. One Dollar a year to other Countries.

Address all communications and make all checks and money orders payable to

The Practical Engineer

46 North Twelfth Street PHILADELPHIA, PA.

The total circulation of The Practical Engineer for the year 1903 was 77,250 copies, an average of 6437 copies per issue. The total circulation for the year 1904 was 132,000 copies, an average of 11,000 copies per issue. The total circulation for 1905 was 182,500 copies, an average of 15,208 copies per issue.

Any Advertiser is invited to examine our Paid Subscription Lists and Post Office Mailing Receipts at any time.

Entered at Philadelphia Post-office as Second-class Matter

CONTENTS.

	PAGE
Brush Holders for Dynamos and Motors	3
Recent Developments in Central Stations	5
Vertical Turbo-Alternators in American Stations	9
Arithmetic for Engineers—Part 5	11
Cause and Effect of Various Points in Valve Setting	12
New Way of Making Phosphorus	14
Practical Hints About the Indicator	15
Parallel Operation of Alternators	17
Cost of Electricity Obtained from Water, Steam, Gas and Oil	18
Centrifugal Pumps	19
Editorials	20-21
Expansion in Steam Pipes	21
Letters from Engineers:	
What Causes Cracks in Boilers	22
Flow of Water into a Vacuum. Use of Slide Rule	23
Pump Lifts	23
Leveling a Boiler	23
A Handy Boiler Room Signal	24
Refuting an Established Theory	24
Care and Operation of Gas Engines	25
Wood Pump Plungers	26
Setting Valves Correctly Did Not Remedy Pump Trouble	26
A Small Shaft Made Large	27
Stronger Springs Cured Pump Trouble	27
A Peculiar Pump Trouble	27
Questions and Answers	29-31
New Power Plant Equipment	31-33
Book Reviews	33

Cool the Engine Room.

Now that summer is drawing near, every engineer should see to it that his engine room is properly ventilated. Working in an engine room with the temperature at 110 degrees or higher is no joke, and even though a man is only partially affected by such a high temperature, it is not generally conducive to the best economy of the plant. If during the time when the engine room is at such fever heat any little thing needs attention, it is only human nature to say, when the perspiration is pouring down one's face, that it is good enough or it's not worth bothering with, and so many times things are neglected which under ordinary conditions would be attended to.

In large cities, where ground is expensive, it is unfortunate that the engine room is usually the last thing often thought of when erecting a building, and many times it is stuck down two or three stories below the pavement, with hardly any means of ventilation. In such cases some means of artificial ventilation should be resorted to, and except in especially peculiar locations, most engine rooms can be made fairly comfortable.

One of the first precautions that should be taken is to see that all possible radiating surfaces are covered with some material which is a bad conductor of heat, and to see that all steam leaks are stopped, as the leakage of steam not only increases the temperature, but also the humidity, of the room, thereby making the heat seem worse than it is. Plenty of ventilation should then be provided so that the fresh air can come in freely and so that hot air can be driven out. There are many expedients that may be adopted by the resourceful engineer, such as the use of an electric fan, or a fan driven from some line of shafting, but whatever means is available, the engineer owes it to himself to have a workroom which is both moderate in temperature and healthful in atmospheric purity.

—o—

The Finance of Engineering.

In many factories the engine which operates the plant is run non-condensing, and the exhaust steam is utilized in warming the building during the winter. When this is done it is generally necessary to put a back pressure upon the engine in order to secure a proper circulation of steam through the radiators and coils. The question which is often asked us in this connection is, "Will it pay to install a condenser and use live steam from the boilers for heating purposes?"

Before answering this question, the existing conditions, such as the cost of water, the length and severity of the winter, the amount of steam required, and the type and position of cut-off of the engine, must be considered. Suppose that a 400-horse power engine is used in the plant, and that steam is required six months in the year to supply 20,000 square feet of direct radiation. Assuming that the boiler evaporates nine pounds of water per pound of coal, that the engine requires thirty pounds of steam to generate a horse power hour, and that coal costs $3 per ton, the problem is reduced to one of calculation. The amount of steam used per hour will then be $400 \times 30 = 12{,}000$ pounds, and $12{,}000 \div 9 = 1333$ pounds of coal will be used per hour, so that the cost of the coal will be $1333 \div 2240 \times 3 = \$1.79$ per hour.

If the engine loses about 20 per cent. in cylinder condensa-

tion, the amount of exhaust steam available will be 12,000 × .80 = 9600 pounds per hour. If the back pressure on the engine is 5 pounds, then its temperature is 228 degrees, and its latent heat is 954 heat units. Since some of this steam must be used in the feed-water heater, which, on the average, will heat the water from 70 degrees to 210, then the number of heat units required to heat the 12,000 pounds of water the engine uses will be (210 — 70) × 12,000 = 1,680,000 heat units per hour, or the number of pounds of steam condensed will be 1,680,000 ÷ 954 = 1814 pounds, leaving 9600 — 1814 = 7786 pounds of steam to do the heating.

In a direct heating system it is usual to allow about one-third of a pound of steam per square foot of radiating surface per hour, so that the 20,000 square feet of heating surface in the plant will require 20,000 × 1/3 = 6666 pounds of exhaust steam per hour, which leaves 7786 — 6666, or 1120 pounds to be exhausted into the atmosphere. This makes the expense of the plant $1.79 for power and heat every hour, and since the same amount of power must be generated in summer as in winter, the surplus steam is wasted in summer and the fuel expense of the plant will be uniform throughout the year when running non-condensing.

When a condenser is used, the first thing to consider is the effect of the lower back pressure upon the cut-off of the engine. The saving due to an earlier cut-off will probably be in this case about 40 per cent., so that the number of pounds of coal required for power will be 1333 × .60 = 799 pounds. To this amount must be added the fuel required for heating and for the auxiliaries used with the condenser. As a cylinder condensation of 20 per cent. has been assumed, and as the saving in water by running condensing is 40 per cent., this will leave 12,000 × .60 = 7200 pounds required, and allowing for the cylinder condensation, the amount of exhaust steam that must be condensed will be 7200 × .80 = 5760 pounds. Assuming that 16 pounds of cooling water will be required per pound of steam condensed, this will equal 5760 × 16, or 92,160 pounds, or 92,160 ÷ 8.3 = 11,103 gallons of water required for cooling per hour. If about 500 foot pounds of work are required to pump each gallon of water from the supply to the condenser, the number of foot pounds required by the pump per hour will be 5,551,500, or 92,525 foot pounds per minute, which is equivalent to 92,525 ÷ 33,000 = 2.8 horse power, and as an ordinary steam pump requires about 120 pounds of steam per horse power hour, this will require 120 × 2.8 = 336 pounds of water per hour, or 336 ÷ 9 = 37.3 pounds of coal per hour.

It has been shown that to heat the 20,000 square feet of direct heating surface, 6666 pounds of steam are required, which, if supplied by the boiler, will require 6666 ÷ 9 = 741 pounds of coal per hour, so that the amount of coal required when running the plant non-condensing in winter will be 799 + 37.3 + 741 = 1577 pounds, as against 1333 pounds when running non-condensing.

To complete the comparison, suppose the factory runs 10 hours a day for 300 days, in which case, if run non-condensing, 1333 × 10 × 300 = 3,999,000 pounds of coal will be required per year, and when run condensing, the amount of coal required will be (799 + 37) × 10 × 150 = 1,254,000 pounds during the six months when no heat is required, and (799 + 37 + 741) × 10 × 150 = 2,365,500 pounds during the six months when heat is required, or a total of 1,254,000 + 2,365,500 = 3,619,500 pounds, leaving a balance of 3,999,000 — 3,619,500 = 379,500 in favor of the condensing plant.

The above calculations merely tend to show the general method used when handling a problem of this kind, and the figures have taken no account of the advantage to be gained in the increased temperature of the feed water when running non-condensing, nor have they taken into account the use of a vacuum system of heating, or the cost or scarcity of condensing water. The use of the cooling tower will also complicate the method of calculation, but by its use many of the disadvantages of the condenser will be obviated while still retaining the advantages of condensation.

The problems of the finance of engineering are the hardest problems to solve of any that come before the engineer, and to be able to solve them, the engineer must have a thorough knowledge of the science of engineering, a clear head for mathematics, and a complete understanding of the conditions involved.

Expansion in Steam Pipes.

Ample allowance for expansion must be provided in all steam pipe designs, as most of the failures that have occurred have been circumferential fractures near the flanges, instead of longitudinal fracture near the middle of length as when the pipe is burst when testing. Such failures are caused by expansion strains, since cylinders are twice as strong circumferentially as longitudinally when subjected to internal pressures.

The simplest method is to provide angles in the line of piping, using fittings with easy turns, and have the legs entering the elbows long enough to take up the expansion. A better method, especially for high pressures, is to design the pipe with bends of long radii, remembering that the thicker and stiffer the material the longer should be the radius. Still another method is in vogue when angles and bends cannot be used, that is, the adoption of expansion or slip joints. Copper pipes seldom require slip-joints, as the material, being both flexible and ductile, can usually be designed so as to receive the required bends. Cast-iron, wrought-iron and steel are, however, so rigid that the required length of bend cannot always be provided, and slip-joints must be made. Some engineers recommend, out of preference, such straight pipes with slip-joints.

Gas producers can be divided into three classes, *viz.:* pressure producers, or those in which a gas mixture is pumped into the producer by an injector or centrifugal blower; suction producers, or those in which the motor sucks the gas from the producer; and combined pressure and suction producers. Of the three classes, the suction gas producer is the simplest, as it does not require a steam boiler, a gas regulator or a gas meter; it takes up less space than the pressure type, it runs without noise, it cannot explode and it is odorless. The efficiency of the producer is about 90 per cent. and the thermal efficiency of the gas is about 30 per cent.

When generators operate at low power factors the regulation is not so good as when the power factor is 100 per cent. and the temperature of the field coils is increased, owing to the increase in exciting current required to keep the voltage normal.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

What Causes Cracks in Boilers?

EDITOR THE PRACTICAL ENGINEER:

Your editorial on "Lap Seam Boilers and Steam Boiler Explosions" in the January issue is to the point. The question is, what makes the cracks? If the proper kind of material is used and the plates are put together without straining, the holes for the rivets being properly drilled, what is there to cause the cracks unless it be the grooving effect found in the boilers as a form of corrosion? Nowodays it seems that the greater part of the explosions are laid up to this matter of cracked plates, but is there any reason why the cracks should be in the seam any more than in any other part of the plate? Only to-day I had occasion to note two explosions that took place in the last year in which the cracks were found about the middle of the plates and had evidently been there for some time, but were so fine that they could not be seen. Of course, we all think that the butt strap joint is the stronger of the two forms, but at the same time it would seem that it covers more of the plates than the lap seam. It is a fact, though, that the part of the plate in this joint relied on to hold is not covered, it being the section of the plate through the outside row of rivets. Even in this case it is possible for the crack to develop on the inside of the plate under the inner strap and thus be covered so that it could not be seen when the internal inspection is made. A crack between the outer row of rivets and the edge of the inside strap might well be as serious as the cracks of a lap seam boiler.

Since it is not possible, therefore, to make a joint that is proof against covering up the cracks if they are formed in certain parts of the plate, it would seem to be the part of wisdom to avoid the cracks altogether, and this can be done only by getting at the root of the trouble and finding what it is that causes the cracks. This is a subject that seems to be given too little attention, in view of the great part the cracks play in causing the unavoidable apparently and disastrous explosions. We hear much of boiler compounds and scale removers, tube cleaners, etc., but altogether too little attention is paid to the matter of avoiding the scale formation altogether, and in stationary plants practically no thought is given to the kindred subject of pitting and corrosion until the explosion caused by grooving (a form of corrosion) brings up the matter and causes the people concerned to give forth long sighs of regret that they did not get enlightenment sooner.

It is true that the principal cause of corrosion is not present in most stationary plants where efforts are made to furnish clean water to the boilers, but in marine practice it is found necessary to give the matter careful thought. In this branch of engineering the chief trouble is found in preventing the destruction of the clean boiler plates rather than to removing scale, and no thought is given to this latter subject except when the evaporaters for making distilled water are to be cleaned. The subject of corrosion is a difficult one to handle, and there is little known definitely as to the causes in many cases. It is found that almost every feed water is a law unto itself in causing this destructive action on the boilers, and no two cases are alike, so that the engineer and investigator must study every instance that comes up, viewing it in the light of all the local circumstances.

Probably one of the greatest causes of the phenomenon known as grooving is excessive stiffness in any part of a boiler or the lack of proper stiffness in any part. Inequalities in the matter of flexibility in the parts set up local stress, with change of pressure and temperature, with the result that the metal is gradually crystalized or hardened so that it becomes too brittle to yield and a crack is formed. This may be a fine line at first and in some cases is almost invisible, so that there is grave danger of its being overlooked in making an inspection. It would seem that the difficulty in detecting cracks of this kind is one of the chief causes of explosions in boilers that have been inspected and insured. It is plain that action of this kind will be much facilitated by the presence of acids or other corrosive agents in the boiler, and when these combine in their action with the destructive effect caused by the mechanical process just described, we may expect the grooves to widen gradually until of a V-shape and then gradually they are eaten out until general corrosion is the result.

E. S. HAWKINS.

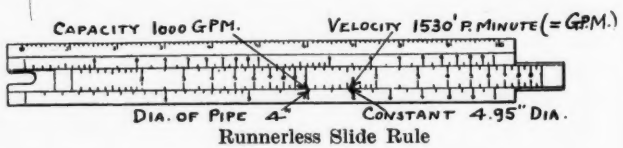
Flow of Water into a Vacuum. Use of Slide Rule.

EDITOR THE PRACTICAL ENGINEER:

Permit me to say the following in reference to your answers to the question of A. S., page 26, December, 1906. Although the answers are correct and to the point, still I read between the lines that it is not merely theoretical knowledge A. S. is after, but some practical data that he can apply to a problem that is before him.

As I understand the questions, A. S. has a pump that is rated at 1000 gallons per minute, and he likes to know whether a 4-inch suction pipe will be sufficient to supply it. What he calls a vacuum is the imperfect vacuum on the suction side of the pump and the velocity into that will be only a fraction of the theoretical velocity given in the answer.

The answer should have been that a 4-inch suction pipe is altogether too small for a 1000-gallon pump. It should be 10"



Runnerless Slide Rule

in diameter, which would give a velocity of 245 feet per minute.

As in problems of this sort absolute accuracy is not required, the slide rule will come handy for giving an answer quickly and sufficiently close.

Of the two kinds of slide rules in the market, namely, the Mannheim and the Runnerless, the latter is the more conven-

ient one and therefore preferred by all those who are acquainted with both types. The advantage of the Runnerless slide rule lies in its power to solve the proportion $a^2 : b = c^2 : d$ in a single setting, and it is this proportion which is most valuable in the solution of engineering problems.

To answer Question 3: "What would be the velocity of 1000 gallons of water through a 4" pipe in one minute," we have the setting of the slide as illustrated in the cut. To explain the setting, we will assume the velocity to be known = 1530 feet per minute. Set 1530 foot velocity on scale 4 over 4.95" diameter on scale 3. The figure 4.95 indicates that diameter of a vessel that contains just as many gallons as it is feet high, or that diameter of a pipe that discharges just as many gallons per minute as the velocity of the water is feet per minute.

As soon as slide is set, change the 1530 from velocity to capacity, and you have a complete table of diameters and capacities from which you can pick out whichever you want without shifting a runner. Thus over 4" diameter we find 1000 gallons per minute, and the decimal value of this answer is determined by that of the velocity 1530.

This setting can be written in the form of a proportion, thus:

Proportion: $4.95^2 : V = d^2 : G.\ P.\ M.$

Example: $4.95^2 : 1530 = 4^2 : 1000.$

and with this setting any of the three terms can be found when the other two are known.

A constant of this sort is easily committed to memory, as it has a distinct meaning, while the constants used on the Mannheim rule are mere figures hard to remember, and give no clue to the decimal value of the answer.

E. Orange, N. J. F. F. NICKEL.

Pump Lifts.

EDITOR THE PRACTICAL ENGINEER:

As we know, theoretically, a pump can lift water about 33 feet, but practically, we are told, it can be lifted about 26 or 27 feet. I claim that a pump will not give a satisfactory flow of water if the water is more than 24 feet below the plunger; it being understood that no suction air chamber is attached. My reason for saying this is as follows: Several years ago I installed a pump where the water was 25 feet 3 inches from the pump. The pump was started and it brought up a small stream of water of about half the volume of the pipe by laboring very hard. I disconnected the pump, lowered it three feet and again started it. This time it gave a full supply of water and ran quite easily. The pump was not equipped with a suction, but all the joints were perfectly tight. A suction air chamber is a thing I do not care to use if I can get a short enough suction, because if the proper working of your pump depends upon the relief such an air chamber will give, it will be almost a certainty that the chamber will be full of water just at the moment when you cannot spare the time to empty it, for they fill with water very often. SCOTTY.

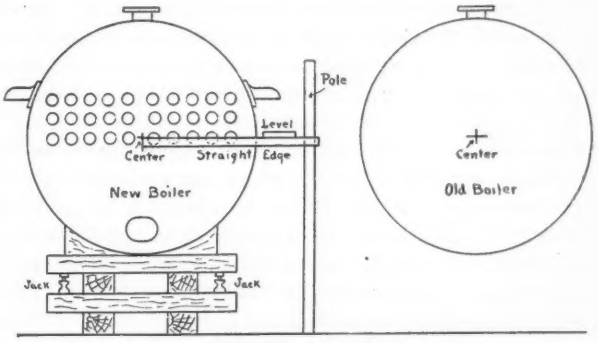
Toronto, Can.

Leveling a Boiler.

EDITOR THE PRACTICAL ENGINEER:

Having had occasion to put in a new 72-inch by 16-foot return tubular boiler recently, I will illustrate the method used for placing the boiler in position and leveling the same ready for the brick work. No attempt will be made to consider the masonry, as that is a job usually left to outside parties, although the engineer should thoroughly understand it in all its details, to the end that if it ever came under his supervision he could successfully handle it.

The boiler was unloaded from the car onto a shoe and was towed by rolls to the desired position; then by suitable jacks

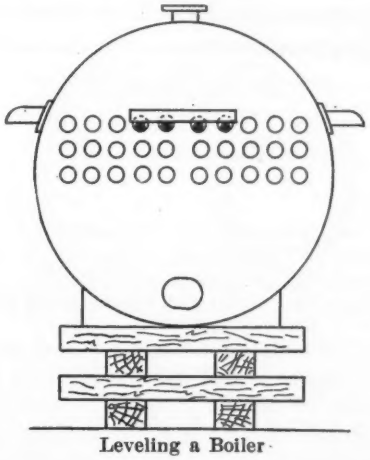


Centering the Boiler

placed, one under each corner of the shoe, it was reared to the approximate height, after first wedging the shoe off the floor and blocking it up. Cribbing, consisting of 8" x 8" blocks, was used to support the boiler and shimmed to get the required levels.

The horizontal distance from the center of old boiler to center of the new one was to be 8 feet 7 inches, and the center of the new boiler 7 feet 3 inches above the fire room floor. The center, both horizontally and vertically, was plainly marked, on front head of the old boiler and the same repeated on new one, it being desirable both from a systemmatical arrangement and sightly appearance to have the centers on the same level.

The requirements for leveling the boiler were a light wooden pole, 8 feet long, a straight-edge, a reliable level and three or four pieces of pipe, say 1-inch diameter and about 4 feet long.



Leveling a Boiler

The 8-foot pole was stood on end on the floor and the straight-edge placed exactly on center mark of old boiler, and the end carried out to cross the pole. A level was now placed along the upper surface of the straight-edge, the same being raised and lowered by an assistant at the end near the pole, until the edge was exactly level. When the edge is level, make a mark on the pole.

The straight-edge was now used on the new boiler in exactly the same manner, and by keeping the straight-edge on the mark on the pole, the jacks were raised and lowered until the center of the new boiler came exactly opposite the level edge, giving the boiler a pitch of one inch at back end to be sure that when the glass shows water there will be sufficient at the other end and to assist in draining the boiler.

The short pieces of pipe were now put into the top row of tubes, a sufficient amount to allow the level to be supported on them without causing them to drop downward by weight of level. The level was applied crosswise on these pipes and the jacks used to get the boiler level.

In the style of setting used with lugs supporting the boiler, it should be seen that the plates, which are placed on the wall for the lugs to bear on, should not be laid level, but given an inclination, or else the plate will raise at one end to enable a whole bearing for the lugs, or the lugs will raise off the plate.

In the writer's opinion, the best method of supporting tubular boilers is to hang them from an overhead gallows frame, in the manner adopted for supporting the majority of horizontal water-tube boilers, thus making them entirely independent of the brick-work.

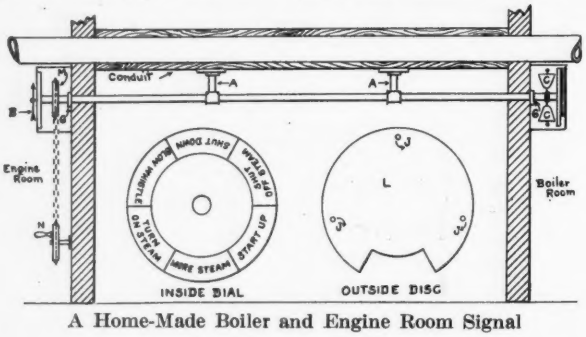
Lawrence, Mass. A. W. B. E.

A Handy Boiler Room Signal.

EDITOR THE PRACTICAL ENGINEER:

I am sending you an original engine and boiler-room signal, which I have used for a number of years. I have enver seen another like it, or one that could give as good satisfaction, and it is especially desirable where the engine and boiler rom are in separate buildings.

This signal is used by the engineer to call the fireman's attention to anything he may desire, such as more steam, shut down, blow whistle, etc. The outside disks, L, are made of heavy galvanized iron, and at the periphery of the disks three ⅜-inch holes J J J are bored about equi-distant. At the bottom a sector is cut out from the disk, about one-sixth of its circumference in length, so that the printed sector on the inside dial may be seen. The holes J J J are for bolts, to secure the outside disk to the wall, so that the inside disks, being smaller in diameter, are free to rotate. The inside dials are secured to a shaft collar on the end of the shaft by three stove screws, which are screwed into the shaft collar. These dials are preferably painted white, with black letters, the sector lines being striped black. The outside disks are painted all black, that the inner disk, or sector, will show more distinctly.



A Home-Made Boiler and Engine Room Signal

Between the dial and the wall on the engine-room side of sketch, is a sprocket, M, and chain, secured to the shaft by a set screw in its hub. Between the boiler-room wall and dial, two bells, C C, are secured rigidly to the shaft by means of a clamp and two pieces of hoop iron, the latter replacing the leather strap on the bells, in order to make them rigid. My engine room is in a separate building from the boiler room, and the main steam pipe is in a wooden conduit, on the bottom of which are two hangers, A A, made of pipe fittings. A floor plate is fastened to the bottom of the conduit, and a piece of pipe of suitable length screwed into it. A tee, bored to fit the shaft, is screwed on the end of the pipe. Both the tee and pipe are then lined up and secured by hexacon nuts, cut from old globe valves. In the engine and boiler rooms are two wall boxes to support the shaft, and a collar is placed at G G, so there will be no end play of the shaft. Should any engineer wish to make this signal system, I would state that the outside disk in the engine room is not necessary. A pointer, B, can be used to indicate the centre of a sector.

To operate the signal, rotate the shaft backwards and forwards once or twice by means of the sprocket N, until the pointer is in the centre of the desired sector, and the fireman will hear it and see what you want him to do.

Adams, Mass. J. W.

Refuting an Established Theory.

EDITOR THE PRACTICAL ENGINEER:

There may be truth in the expression, "There is nothing new under the sun," and it doubtless is accepted by many persons as absolutely true. A little reflection will show, however, that the expression is one of sentiment rather than one of principle. For instance, we have no account, legendary or written, that the ancient people had any knowledge of gun-powder; there is no historical information that the ancients had any knowledge of the steam engine, as developed by Watt and Newcomb. To these comparatively new things may be added the telegraph, telephone, electric light, trolley cars, wireless telegraphy, and many other useful and indispensable appliances which may truthfully lay claim to being "new under the sun." But notwithstanding their usefulness now, the steam engine is but little beyond its centennial birthday, the telegraph is less than seventy years old, the trolley car only twenty, and so on. If anyone, five years before the invention of many of these things, had made announcement of the prospective results, they would have been received by the people at that time as the dream of a visionary theorist.

I have been led to write the above, after visiting a plant in which an appliance is in use which refutes an accepted theory; that is, that the waste or flue gases can be secured and converted into fuel to the extent of saving largely in raw material. It has taken years of patient work, study and considerable money to demonstrate that the waste gases, now permitted to flow out through the smokestack to the open air, are of value as fuel, but it is being done at this plant, and tests which have been made show an efficiency of 27½ per cent. over the amount of fuel formerly used.

The principal which makes success certain is the one which mechanical engineers have been wishing for during the last fifty years; that is, the absolute control of fresh air for combustion which is thoroughly mixed with the waste gases. Practical men looking at this plant in working order might

conclude that they could not apply it successfully, but it only involves an application of the draft without the waste usually attending force draft systems. It uses a mechanical draft, but is neither a forced or induced draft.

One reference which will show how a system of controling complete combustion is capable of fine development is the kerosene lamp. This lamp can be made to show the results of incomplete combustion and the so-called complete combustion represented by the white flame and the absence of smoke. The heat energy in passing out the lamp chimney is considered of no value because all the carbon has been consumed. That claim is not true, however. If a plate of porcelain or any cold substance is held a few inches above the lamp chimney, soot will collect on the plate, which is nearly, if not altogether, pure carbon. So the waste gases in passing up a smokestack contain a large percentage of fuel in the shape of soot, if they were suddenly lowered in temperature. Smoke is *gas* chilled or lowered in temperature; soot is *smoke* chilled or lowered in temperature.

The carbon oil lamp demonstrates that if the wick is turned down, the slightest bright flame becomes smoky and the heat falls, indicating a lack of fuel for the amount of fresh air to consume it. If the wick is turned up too high, smoke pours out of the chimney, indicating a lack of fresh air to consume the gas, yet the temperature is high enough to produce the gas. Smokeless fuel, both anthracite and coke, will give off slight volumes of smoke if large quantities are put in bright incandescent fuel. If either should be used under a steam boiler, the temperature of the flue gases at the ends of the flues will be the same as when bituminous coal is used. That temperature is absolute, no matter whether the fuel is solid, liquid, or gaseous. One hundred pounds steam will require at least an exit temperature of from 450 to 500 degrees, and frequently more. Now in the arrangement above referred to, a part of this waste heat is regained.

Investigators searching for definite information along the various lines in nature's storehouse often spring surprises on their fellow-men. Something cannot be secured from nothing, but its form may be changed and the admission of fresh air to the carbonic acid gas demonstrates that there must be something more in the air and something in the unconsumed gases now allowed to pass out a smokestack—something of which we know not of—but by uniting them in a manner conforming with natural laws and with the aid of mechanical appliances positive results can be obtained and a great waste turned into a large saving. C. S.

Irwin, Pa.

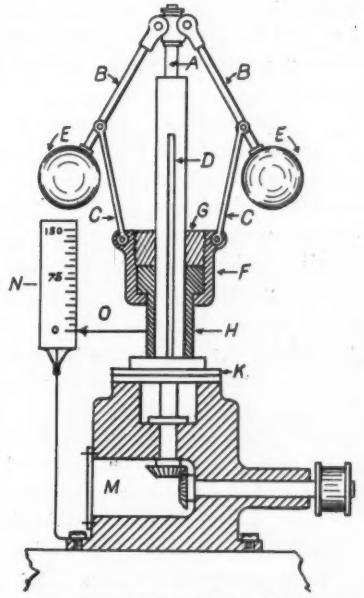
Care and Operation of Gas Engines.

EDITOR THE PRACTICAL ENGINEER:

It may be interesting to some of the readers of your valuable paper to write a few lines about our gas engines, and the care and operation of same; as it is a well-known fact that gas engines have of late years come to the front as motive power, and it is evident from the progress they have made in the past that the future looks very bright for them.

Our plant consists of two 610-horse power gas engines of the Crossely type, and one set of producers rated at 1500-horse power. This plant has been in operation about six months. During that time we have had very little trouble with the engines and no trouble whatever with the producers. I don't intend to take up all the points in the care and management of such a plant, but will give a general outline of it. It is often stated by salesmen that all that is required in the plant where these units are installed is to start the machinery, keep it well lubricated, and when 6 P. M. comes shut down and go home. This is not so with the gas engine, for they require more care than the steam engine, and if attention is not given to the engine, both man and engine will land on the rocks.

The principal thing to keep in mind is cleanliness of cylinders, proper adjustment of main crank and cross-head connections, so that there will be no interruption with compression, for the smooth running of a gas engine depends, to a certain degree, on close keying, proper adjustment of igniters, and the proper mixture of gases. It will be found in practice that gas engines will behave very bad at times, and no cause can be given for the trouble. A few days ago one of our engines began to slow down in speed from 140 to 130 R. P. M., while the other engine remained at normal speed. The only difference in the running of the two engines, the one above mentioned began to pound a little more than usual. This occurred for about ten minutes, and then the pounding stopped and the



Speed Indicator for Gas Engine

engine increased in speed to 140 R. P. M., normal. After shutting down for the night the inlet valve was taken out and examined, also the piston and cylinder. It was evident from the inspection that the carbon had formed on the end of the piston in a peak; which was caused by the oil mixing with it and becoming hard, forming a torch and igniting the charge too early on the compression stroke.

In any gas plant it is a very important factor to know the speed of the engine at all times, and in order to tell at what speed the engine is running, a speed indicator or tachometer is necessary. The tachometer must be driven from the main shaft by belt or gear, and the speed indicator can be used on the shaft also.

I come to the conclusion to make a speed indicator that is driven from the cam shaft by belt, and located on the side frame of the engine, where it can be seen at all times by the oiler or engineer.

The construction of it is as follows: As will be seen by the sketch, it is made in the same form as an ordinary fly-ball governor and revolves at a speed of 120 R. P. M. The height of the governor over all is 8 inches, a scale as shown at N, with figures representing the speed from zero to 150 R. P. M. is supported by a small rod made fast to the base of the governor. The weight of the balls and arms are taken up by the collar K. This has a bearing on a hardened steel plate, not shown in the sketch. The two gears match nicely, and there is no weight or unnecessary friction. The pulley shaft is made of steel and revolves in a long babbitt box. The joint at K can be taken apart and the stem taken out by removing the gear through opening M. A long key is set into the governor stand as shown at D, and this keeps the sleeve H from turning but free to move up or down. The larger part of the sleeve at H forms the bearing for the shell F, that revolves with the governor. The plug G is threaded and screwed into shell F.

The operation is as follows: As the balls fly out tangent to the governor stand, shell F is raised and carries sleeve H with it. The point at O registers the speed of the engine. Several tests were made and several changes before the proper lift of sleeve H was satisfactory. The arms CC, BB, and balls EE are designed so that sleeve A will move up 1¼ inches; thus the speed of the engine is known at all times by a glance at it.

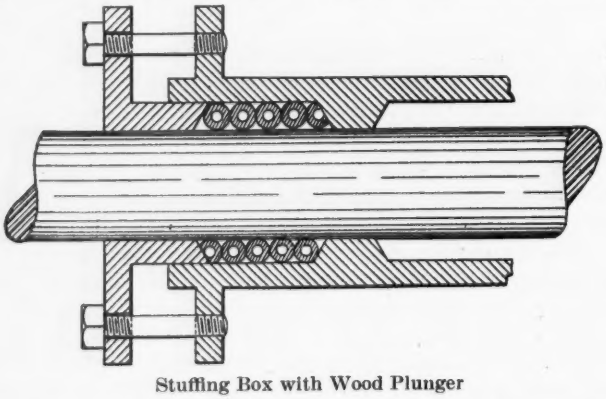
Cambridge, Mass. W. A. D.

Wood Pump Plungers.

EDITOR THE PRACTICAL ENGINEER:

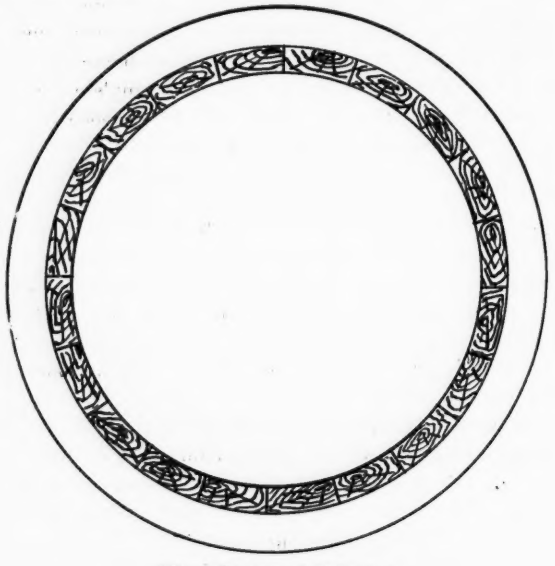
In the anthracite coal-mining district of Eastern Pennsylvania, the mine waters contain sulphuric acid and have a considerable corrosive action on the pipes and pumps. The valves and valve chambers, cylinders, plungers, etc., must be specially designed for the service. The valves are generally made of a special bronze composition, while the cylinders and valve chambers are most generally lined with wood.

For handling the water required in the coal washeries, plunger pumps are often used, having hollow cast-iron cylinders for plungers, which work in hemp-packed stuffing boxes. As the maintenance of the cast-iron plungers, where handling the acidulated water, is sometimes a considerable expense, one enterprising manager of a large coal washery hit upon the plan of using wood plungers. A green log was cut from a



Stuffing Box with Wood Plunger

green tree, this being the most convenient wood to procure, and turned it in a lathe to 12 inches in diameter. The wood cylinder was mounted in the pump to replace the worn-out cast-iron plunger. Hemp packing was used in the stuffing box and the regular pump oil was used for lubrication. The end of the plunger was cemented to prevent the water from passing through the pores of the wood when the pump was operating under pressure.



Wood Lining of Cylinder

The results from the use of the wood plungers have been very gratifying. The life of the wood plungers is about five times that of the cast-iron ones and the cost of a wood plunger is about one-twenty-fifth as much as that of a cast-iron plunger. Pumps having 14-inch wood plungers are also used.

The accompanying sketches show the general arrangement of the wood plunger, the stuffing box and the cylinder. The wood lining of the cylinder is also shown. The lining is made of white pine and is about ½ inch thick. The staves are made from one to two inches wide. After being put in service, the cylinders should be kept filled with water, otherwise if the staves are allowed to dry out, they will become loose and the lining must be reset.

Scranton, Pa. F. W. B.

Setting Valves Correctly Did Not Remedy Pump Trouble.

EDITOR THE PRACTICAL ENGINEER:

I wish to thank J. R. W. for his information given me in the March number of THE PRACTICAL ENGINEER. If he were to refer to my request in the January issue he will find that I have set the valves of the pump as carefully as I can under the instructions which were given me by the manufacturers of this pump, which are as follows:

"Move the steam piston towards the steam cylinder head until it comes in contact with the head; mark with a scriber on the piston-rod at the face of the stuffing-box follower on the steam end, then move the piston to its contact stroke on the opposite end and make another mark on the piston-rod exactly half way between the face of the stuffing-box follower on the steam end and the first mark. Then move the piston back until the middle mark is at the face of the piston-rod stuffing-box follower on the pump end. This operation brings the piston exactly in the middle of the stroke. Then take off the steam chest cover, place the slide valve in the centre exactly over the

steam ports. Place the slide valve nut in exact centre between the jaws of the slide valve, screw the valve rod through the nut until the eye on the valve rod head comes in line with the eye of the valve rod link, slip the valve rod head pin through head and the valve is set."

If he could suggest any other method of setting the valves of this pump I would thank him to do so, as I thank him for his previous information, and I assure him I will follow his instructions.

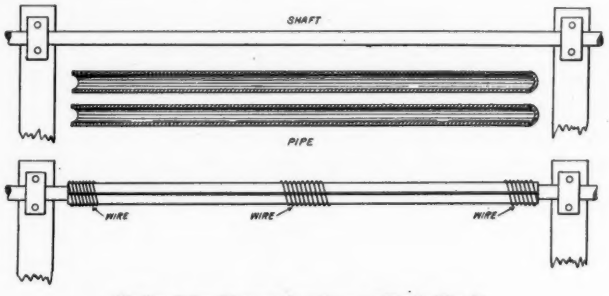
I would also like to ask if there could be a possibility of the metallic packing rings being worn so as to cause this trouble? B. L. K.

Albany, N. Y.

A Small Shaft Made Large.

EDITOR THE PRACTICAL ENGINEER:

A year ago I had charge of a wood-working installation which had a small shop apart from the main building, and the power was transmitted by a 1 3/16 shaft running overhead on post supports. The work which it had to accomplish was far above that which such a size shaft is supposed to carry, but as the different machines were added, the shaft was furnished with more boxes and supports, and by that means was still able to transmit the power needed. During one of the busy times, however, it became necessary to remove two of the supports for the opening up of an alley between the two buildings. This left the shaft too weak, and it would swing in a circle as the speed increased.



Method for Strengthening a Weak Shaft

To strengthen the shaft and stop it from swinging, I took a piece of 20 feet, 1¼-inch common gas-pipe, and with an 8-inch circular saw, which was out of business, ripped the pipe the full distance down the centre. I placed these pieces over the shaft and wrapped them well at the ends and middle with soft copper wire. The shaft no longer swung in a circle while running, but transmitted the power as before. The whole scheme was accomplished in less than an hour. With the exception of having the temper drawn from the ends of the saw teeth, it was left in no worse condition than before.

North Bend, Neb. G. M. V.

Stronger Springs Cured Pump Trouble.

EDITOR THE PRACTICAL ENGINEER:

Being much interested in the questions that were asked F. S. H. by an inspector in Massachusetts, as published in the January issue, I would like to make the cause of the pump trouble plain to him.

Once, when I was employed in a small pumping station in Massachusetts, a similar thing happened there. In the station there were three compound condensing duplex pumps each of 1,000,000 gallons capacity per 24 hours. We carried a boiler pressure of 80 pounds and pumped water to a reservoir against a head pressure of 75 pounds. The water supply was obtained from ponds, and filter beds were used.

Now it happened that we wanted to renew one of the beds as quickly as possible, so it was decided to disconnect one of the pumps and connect it to the bed to pump it out. The suction pipe being connected to the bed, the discharge was led a small distance from the station, so that the water would run down a slope from the station.

When all was ready the pump was started, but it would not pump water. The superintendent, who was in charge of the plant, held a special license for the place and knew all about pumps and water works—so he said. Well, when the pump wouldn't work, the air was blue, green and red by spells around there. First, he said that the men, in making up the joints, had not cut out the centre of the gasket so that the water could pass through the suction pipe. Finding that was not the trouble, he said the valves needed setting; so we set them, but the pump wouldn't work. One of the assistants suggested trying new springs, but the superintendent said he knew the springs were all right. After spending a day and one-half trying to make the pump work, he had new valves and new springs put into the pump, when it pumped water to the queen's taste. The superintendent then said it was the valves, and everybody said "yes," although we knew the old valves were O. K. and worked all right three days before against a head of 75 pounds.

The way I figured the cause of the difficulty was this: The springs, being worn out, were not strong enough to seat the valves when working against the atmosphere alone, and the pump simply churned the water. But with a head pressure to work against, the pressure helped the springs and the pump worked all to the good.

I think of F. S. H. will see that if the pump had stronger springs it probably would work all right.

Boston, Mass. E. R. S.

A Peculiar Pump Trouble.

EDITOR THE PRACTICAL ENGINEER:

Among all the troubles experienced with steam pumps, which are so numerous and which are caused from such a variety of detail, all are mostly capable of a general classification under a few specific heads, principally, steam distribution, packing, water-end condition, breakage of parts and suction conditions. There is, occasionally, a trouble from a cause so unusual as to give us the most difficulty in its location and remedy, many of which give a very emphatic illustration of what a great effect may result from an apparently trivial cause. One of these unusual accidents is detailed below.

The pump in question was a Guild & Garrison duplex flywheel, 12 inches steam, 16 inches air, and 9 inches stroke, serving as a vacuum pump on the second pan of an 8-foot double effect evaporating cane juice, under control of a flyball governor and making about 35 revolutions per minute, maintaining a vacuum of about 27 inches in the pan.

On making my rounds one day I passed this pump and gave the usual hasty glance to see if all looked well, and passed on. Inside of a few minutes I was called by the attendant and

told that his vacuum pump had stopped from some cause which he could not locate.

On reaching the pump with him, I inquired if it stopped suddenly or gradually, and if there was any shock, this with a view to getting a clue to the probable cause. He claimed it stopped suddenly and without apparent shock. Here was, seemingly, a case of steam being suddenly cut off, or some means of the proper distribution crippled.

I tried the steam stop valve to find if some one had closed it, but found it wide open. It had an arrow on the body which indicated that the way it was placed it would still be open if the disc was off the spindle. Then I looked at the governor to see if its valve spindle had got unhooked, allowing it to close by falling, but found it all right, unless its valve had got off the spindle. Then upon opening all cylinder cocks, steam blew momentarily from all, but in a few moments those which should have steam on in that position of cranks kept on at apparent full pressure. (There was about three pounds back pressure which we always worked against, which, of course, continued.) Apparently the steam was on and properly distributed. An examination of the bell cranks which operated the slide valve spindle to see that they had not slipped, showed them in proper position. I next looked at the eccentrics and found them correct, with marks on the shaft which I had placed there before, for just such an emergency. Here, again, with all steam on, in the right place, proper pressure, no apparent unusual resistance, the pump would not budge. Then taking off both steam cylinder heads to see if a nut was off the rod, or a bolt out of the steam piston, although neither piston was in position to strike such an obstruction, but found the pistons all right. The great clearance in the air ends of these pumps made it useless to look for any obstruction there.

I then did what it appeared I should have done at first—shut off steam and exhaust valves and turn the fly-wheel by hand. This proved impossible, things feeling as though they were permanently fastened in that position. Then disconnecting one pump rod from its crank, I tried again to turn the fly-wheel, which again proved impossible. Then I disconnected the stubborn side and coupled up the other, and tried to turn again. The fly-wheel shaft and one pump turned clear. This located the trouble, and a pretty solid one, in connection with the rod or one of the two pistons on one definite side.

An examination of the forward, or crank end clearance space in the air cylinder, proved there was nothing to look for there, as even the nut on the pump piston rod was on the other end. I opened this end first, because it was easy of access, through a small hand hole which gave access to the plate or deck of the suction valves, which open downward toward the cylinder. After opening this hole I ran my arm around the clearance space and against the piston, which was near mid-stroke, and found quite a section of valve spring wire, about No. 10 or No. 12 brass wire, jammed between the air piston and the top wall of the cylinder. This looked small, but very suspicious. I had my men take a piece of 6 x 6 wooden ram and butt the crank end of the rod, which was free, and drive the piston off the wire. After this operation everything was clear. Of course, all the slack between the piston and wall was on the top of the cylinder—the only place where the worn taper end of the spring could get in. The spring could only have been thrown to the top of the cylinder by the commotion of the water when the piston reaches the end of its stroke and finds the clearance space filled (solid at this point), with the water used for lubrication and valve-sealing on this class of pumps. This instance furnishes, perhaps, the one chance in a million where such a thing would occur.

After about thirty minutes loss of time with the pump, and the "effect" which it served, and a small stoppage of the sugar mill, we finished a very little wiser, as in any other trouble one would naturally begin his investigations for causes in proportion to their relative probability.

Many times, both before and since, I have found pieces of springs which had wallowed around in such cylinders for weeks, but this was the first to cause so much trouble. It seemed peculiar that this piece should offer sufficient resistance to prevent the piston from ploughing a score in the cylinder.

To make matters worse, we had visitors in the sugar house that day, and that the vacuum pump should select such an occasion for its first difficulty seemed an irony of circumstances.

A. L. H. T.

New Orleans, La.

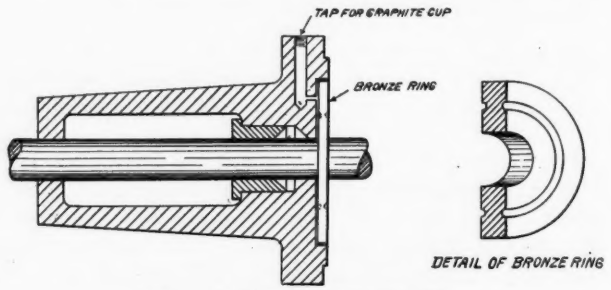
—o—

Remedy for C. E. A.'s Valve Stem Trouble.

EDITOR THE PRACTICAL ENGINEER:

In answer to C. E. A. in the February number, we have had similar trouble on a four-valve automatic Erie engine, the only difference being that the stems on our engine go from bonnet to bonnet and fit in slots in valve, and the ring is solid on the stem.

Now the first question to come up is this: To what pressure is this ring subjected? Let us think it out on these lines, taking figures at random. Let us say steam pressure, 100 pounds; stems, 1½ inches diameter, or 1¾ square inches, nearly; ring, ⅜ inch wide, or 2.2 square inches, nearly. Then $100 \times 1\frac{3}{4} = 175$ and $175 \div 2.2 = 80$ pounds per square inch, nearly. As these bearings run nearly dry and leak steam, this is too much.



Remedy for Valve Stem Trouble

I would suggest that he make this bearing just as large as possible and make the ring of bronze, leaving out all oil grooves except one on each face, all the way around and 1/16 inch deep and across, for oil and water packing, as shown in sketch. We did this and it proved out all O. K.

Now the pressure on these bearings is entirely due to the area of hole and pressure of steam. The size of the cover makes no difference and the makers of our engine claimed that if we increased the size of bearing it would so increase the friction as to break the gear. Well, we increased it until we have about 22 pounds per square inch, and nothing is broken yet.

We drilled the bonnets and put on graphite cups, as per sketch, but after smoothing by use, they need hardly any.

Now C. E. A. need have no fear to try this, as it will stop the trouble as it did ours; and if you do try it, I wish you would let us know the results through THE PRACTICAL ENGINEER.

Another thing you can do which will help some is to pump in a good supply of oil; close throttle quick, when the stem will give away enough to let the oil in. You can do this and not stop motion if quick about it.

Groton, N. Y. M. E. Y.

Measure of Engineering Ability Depends Upon Standard.

EDITOR THE PRACTICAL ENGINEER:

I have read with increasing interest the communications from several practical engineers on the subject of theoretical knowledge, catalogue information, and practical experience. As I look at the matter, there is more or less friction and unkind feeling between the theoretical man and the man that styles himself practical than there should be. The man who has no knowledge or qualifications except those that are derived wholly from books is about as useless an article as can be imagined. The man who has a correct knowledge of principles, and has taken the pains and the time to incorporate said knowledge with a fund of practical experience, is in a position to rise in his profession and become a successful engineer.

A correct knowledge of underlying principles is of vital importance in engineering work, and its value can hardly be overestimated. The other qualifications that an engineer should possess will depend largely upon his calibre and the character of work he is called upon to perform.

An engineer may be all right in the position that he is filling for the same reason that a steam gauge on his battery of boilers is all right for the duty that it is expected to perform. The steam gauge for the boiler room is not an instrument of precision and men that are alive to their own interests make it a point at intervals, more or less frequent, to compare it with a standard so as to determine its amount of error. Similarly a man who has an engineer in his employment should have his plant inspected at intervals by a man that is a thorough master of his business.

As for my own training, I would say that most of my knowledge has been derived from reading the best books on engineering subjects, catalogues included, but not swallowed whole, and from visiting engine rooms and talking for hours at a time with the best practical men, both in locomotive and stationary engineering. And I must say that I have had but little friction between the theory and practice, as the class of men I met seemed to be desirous of connecting the one with the other. In the numerous discussions that I have heard, there was never a hitch with the men that were really practical.

In enginering lines, like everything else, it all depends upon the standard with which things are measured.

N. Adams, Mass. T. H. R.

A Correction.

In the February issue, the answer to the problem in cancellation, under the subject of Arithmetic for Engineers, should be

$$\frac{21 \times 28 \times 54 \times 9 \times 6}{4 \times 7 \times 9 \times 42 \times 45} = 3\ {}^{3}/_{5}$$

instead of 6 as was given.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

How High Will the Water Be?

EDITOR THE PRACTICAL ENGINEER:

I submit the following problem, which I would like some of your engineering readers to answer:

Suppose a tank is 30 feet deep and has a water pipe extending from the top down 25 feet within 5 feet of the bottom of the tank. The pipe is air-tight except at the bottom end, and has an ordinary pressure gauge at the top. The tank is open at the top. If water is pumped into the tank, how high will it be in the tank when the gauge shows 5 pounds pressure?

I had a similar arrangement on top of the water works standpipe here connected with a battery and bell in the engine room seven-eighths of a mile away, using the water pipe for one circuit and wire for the other, arranged to ring when the water was 8 feet from the top.

I think this problem will puzzle some of the high school boys of these times. A. R. G.

Middleboro, Mass.

What Caused this Governor Trouble?

EDITOR THE PRACTICAL ENGINEER:

Will some reader of THE PRACTICAL ENGINEER please give me the remedy for the trouble of the governor of a 12" x 30" Corliss engine running 50 revolutions per minute? The governor acted like this: When the engine was started it would run fine for about five minutes, then it would start to race until the governor was carried to its highest position; then the engine would slow down so that when the governor acted again it would bring the safety cam into play, thus preventing the valves from opening, causing the engine to stop. The load on the engine varied but little. A. C.

Hornbeak, Tenn.

Size of Pump Cylinders. Thickness of Boiler Shell.

EDITOR THE PRACTICAL ENGINEER:

Will you please answer the following questions:

1. What minimum size pump would be required to force water up an 18-inch vertical pipe 500 feet long? What I want to know is how to work out size of pump from a given head.

2. If a boiler is 30 feet long and 36 inches in diameter, joints single riveted, holes punched, working at 80 pounds pressure, what should be the thickness of the sheet?

3. What is the working load of 2⅛ steel rope?

A. F.

1. The data given in this problem is insufficient because it does not explain how much water is required to be pumped. As

the head is 500 feet, the pump must pump against a pressure of $500 \times .434 = 217$ pounds per square inch. If the steam pressure in the steam cylinder was 100 pounds per square inch, then the area of the steam cylinder would have to be 2.17 that of the water cylinder, allowing for no slip. If, however, the efficiency is taken at 60%, then the area of the steam cylinder should be $2.17 \div 0.6 = 3.61$ times the area of the pump cylinder. If the quantity of water to be pumped is known, the volume of the water cylinder can be easily worked out and the steam cylinder made 3.61 times larger. Since the stroke would be the same, the problem resolves itself into finding the ratio of the areas of the cylinders.

2. The thickness of a boiler shell can be worked out from the formula

$$t = \frac{p\,d}{s \times .65}$$

in which t = thickness of plate, d = diameter of shell in inches and s = safe working stress in pounds per square inch, .65 = the efficiency of a single riveted lap joint, and p = working pressure in pounds per square inch. If the safe allowable stress be taken at 14,000 pounds, the thickness becomes

$$t = \frac{80 \times 36}{14000 \times .65} = .316$$

or about 3/8 of an inch.

3. About 28 tons.—[Ed.]

Safe Speed of Fly-Wheels.

Editor The Practical Engineer:

Is there a rule for finding the safe speed of a flywheel, or is there a limit for the speed of a flywheel on any stationary engine? You will confer a favor upon me if you will kindly answer this question. H. A. S.

Tacoma, Wash.

The maximum allowable velocity of the rim of a flywheel is usually taken as 6000 feet per minute. If, therefore, the number of revolutions of an engine is known, the maximum diameter can be calculated from the formula,

$$D = \frac{6000}{3.1416\,R}$$

in which D = diameter of the wheel in feet and R = number of revolutions per minute. If the engine makes 100 revolutions per minute, this will limit the diameter to about 20 feet, and if the engine makes 200 revolutions per minute, it should not have a diameter over 9 feet.—[Ed.]

Russell Automatic Governor.

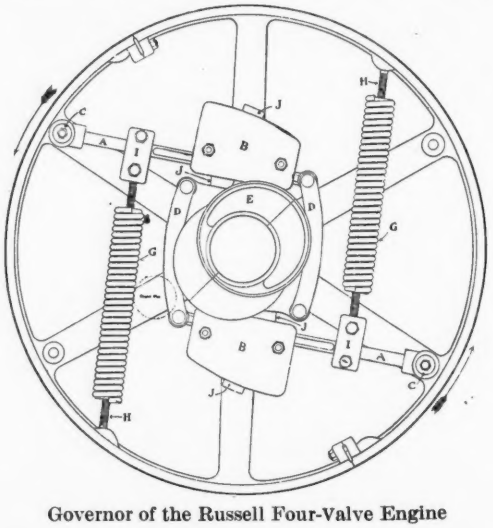
Editor The Practical Engineer:

Will you kindly explain through your valuable paper the working of a Russell governor and how to set same?

Lewisville, Wash. W. T. S.

The type of governor used on the Russell four-valve automatic cut-off engine is shown in the accompanying sketch. The weights B are clamped on weight arms A, which are fulcrumed at C to the arms of the governor wheel. The links D couple the weight arm to the ears in the sleeve of the cut-off eccentric E, which is free to turn on the shaft, and can be turned 100 degrees by the movement of the weight arms to the outer extreme of their range.

The governor controls the speed of the engine through the cut-off eccentric E, which fits loosely on the shaft and is connected to the weight arms in such a manner that the cut-off eccentric is moved around the engine shaft, either forward or backward, as the weights change their position, thereby cutting the steam off earlier or later in the stroke as the governor



Governor of the Russell Four-Valve Engine

weights adjust themselves to the load. When the cut-off eccentric rotates around the shaft in the direction the engine runs, the steam is cut off earlier in the stroke; when the eccentric is rotated backward, the steam is cut off later in the stroke. The extreme range of cut-off is from zero to about 5/8 of the stroke, where it meets the fixed cut-off of the main valve.

When the spring tension is increased to secure regulation the clips I should be moved back toward the fulcrums C, or the weights B should be moved outward to prevent increase in speed. The springs G are of tempered steel wire and are adjusted by means of the tension screws H. The weight arm stops J prevent the weights from exceeding their range of action.

Regulation is secured by adjusting the springs G, but in order to give the governor stability combined with sensitiveness the spring tension should be decreased just enough to give the maximum allowable drop in speed from no load to full load. If the change of speed is too great with change of load, the proper remedy is to increase the spring tension.

Piston Valves. Lift of Pump.

Editor The Practical Engineer:

Please answer these questions:

1. What are the advantages of a piston valve?
2. Why won't a pump lift 60 feet as well as 30 feet?

Beverly, Mass. G. D.

1. One of the principal advantages of the piston valve lies in the fact that it is always balanced against the steam pressure in the steam chest. The only resistance to the motion of a piston valve is its own friction, no matter how great the steam pressure may be. The power necessary to move an ordinary slide valve is measured by the area of the valve multiplied by the pressure and by the coefficient of friction between the

valve and its seat, which, unless steps are taken to diminish it in large engines, becomes a considerable quantity. The use of the piston valve is one method taken to overcome this difficulty. Owing to the fact that a piston valve is balanced it can be lengthened so that the steam passages may be shortened and the clearance thereby lessened without increasing the friction of the valve.

2. Because nature will not allow it. If a pump piston creates a perfect vacuum, the maximum height to which the pressure of the atmosphere will raise the water is about 34 feet, so that it is impossible to lift water higher than about 30 feet, owing to mechanical construction of the pump and friction in the pipes.—[ED.]

Losses in Injector.

EDITOR THE PRACTICAL ENGINEER:

What are the usual losses in an injector running under the best conditions? G. C. S.

Lagrange, Ind.

Outside of some radiation loss, the thermodynamic efficiency of an injector is 100 per cent. Any loss of heat due to the friction of water in passing through the injector is taken up by that water and carried back to the boiler, so that if conditions were ideal, the energy in the steam which is used to drive the water into the boiler is entirely returned to the boiler in the form of hot water.

Steam Pressures.

EDITOR THE PRACTICAL ENGINEER:

Please answer the following questions in your next issue:

1. To what pressure can steam be raised by the ordinary method of firing under a boiler?

2. If the steam gauge shows 100 pounds, how much pressure will there be on a boiler?

Covington, Ky. C. R.

1. Any steam pressure that the boiler will stand.

2. On every square inch in the interior of a boiler there will be a pressure of 100 pounds per square inch.

The Edison Electric Company, of Los Angeles, has practically finished a 60,000-volt transmission line from its 25,000-H. P. hydro-electric station on the Kern River, a distance of 128 miles from Los Angeles, consisting of six cables carried on steel towers from 30 to 75 feet high. The power house, which is built of concrete, with iron roof, is equipped with five three-phase generators, each of 3200 K. W., direct connected to hydraulic turbines. The canal is about twelve miles long, with a carrying capacity of 700 cubic feet per second and a head of 270 feet. Five sets of step-up transformers are used, each 2250 K. W. The transformer station in Los Angeles has four compartments, each containing three transformers of 750 K. W. each. The power thus transmitted is used in the operation of street railway cars over the Loss Angeles city and interurban lines.

R. J. Kellog, of Bethlehem, superintendent of the Pennsylvania Cement Company, was nearly blinded recently by particles of glass from an exploding water gauge.

The Williams Feed Water Regulator.

When feeding water to a boiler or boilers it is essential, in order to secure the most economical results, to feed the water to the boilers in exact proportion to the evaporation and steaming capacity of the plant. A variable water level, caused by irregular and intermittent introduction of water into the boilers, results in loss of economy due to fuel waste and decreased power of the engine per pound of steam supplied. If the water is carried too high, the boiler will prime, and any water due to this cause is absolutely useless as a driving force in the cylinder of the engine, and besides it has a cutting effect on the engine cylinder. If the water is carried too low, it has a more or less ruinous effect on the boilers.

In general practice, where no feed-water regulator is used, it is almost impossible to attain the ideal condition of a fixed water level, as it requires the constant attention of the engineer or boiler attendant to regulate the feed pump to meet the demands of steam upon the boiler, and when the feed pump is located some distance from the boiler, the proper regulation of the water supply becomes almost impossible.

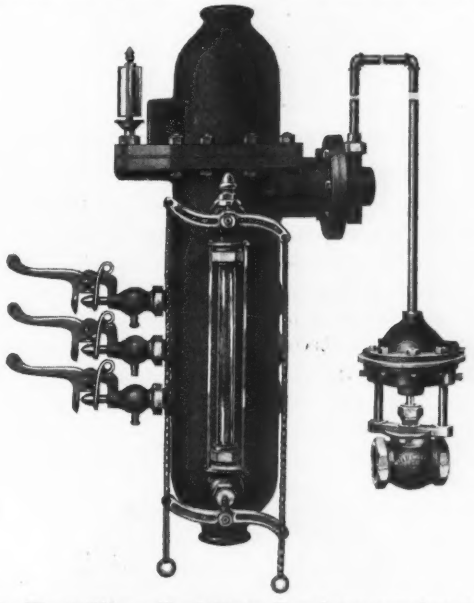


Fig. 1—The Williams Feed Water Regulator complete with Gauge Cocks and Water Gauges

A device which regulates the feed-water supply is the Williams safety feed-water regulator, manufactured by the Williams Gauge Company, Pittsburg, Pa. Besides the regulating feature, the device contains within itself a high and low water alarm, and entirely dispenses with the safety column, as it takes the place of this type of apparatus. Fig. 1 shows the apparatus complete with gauge cocks and water gauges, and Fig. 2 shows the internal construction, the regulation of the feed water to the boiler being controlled by the controlling valve shown at the right of the regulator.

The operation of the regulator is as follows: When the water falls from condensation or other cause, the float, being controlled directly from the rise and fall of the water, drops in exact proportion to the fall, opening the exhaust valve and relieving the pressure from the controlling valve, allowing the latter to open and admit water to the boiler. As soon as the water reaches the required height, the action is reversed, the

exhaust valve being closed and inlet valve open, admitting steam to the top of the diaphragm and closing controlling valve in the feed pipe. This operation continues indefinitely, or as long as there is pressure on the boiler. The variation cannot

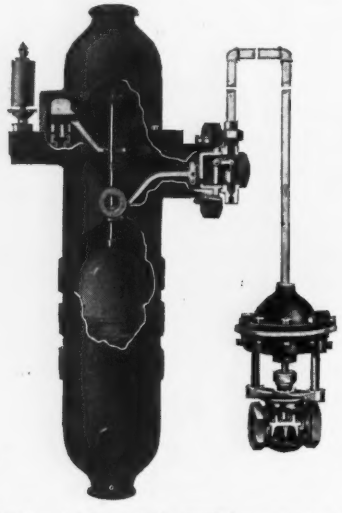


Fig. 2—Sectional View of the Williams Water Column and Regulator

exceed more than ½ inch. Should the pump pressure fail from any cause, the float will drop to the bottom gauge cock, opening the whistle valve, and alarms are sounded from a 1½-inch whistle, which will blow continuously until the boiler is again supplied with the normal amount of water. On the other hand, should the regulator become inoperative from any cause and allow the water to rise too high, the whistle is again brought

Fig. 3—How Williams Floats are made

into action by the rise of the float. The float of the Williams regulator is made of a special construction, having interior partitions, as shown in Fig. 3, which stiffen and strengthen the shell. They are tested to 1250 pounds water pressure and will stand 750 pounds steam.

For plants which already are equipped with safety water columns, an auxiliary regulator is made by the same company. It operates exactly as the safety regulator, but has not the alarm feature, nor gauge cocks and water gauges. The operation is, however, precisely the same. In this device there are no stuffing boxes or expansion tubes. All parts used are of extra heavy design. Springs are not used to close the valves, and the controlling valves are made with nickel seats, which are not corrodible.

As a result of the use of these feed-water regulators it is claimed that besides minimum boiler and engine repairs and absolute insurance against dashes of water in the engine, tests have shown a fuel economy of from 3 to 12 per cent. over hand regulation.

———o———

Large Swartwout Steam Separators.

The accompanying illustration represents one of the 14-inch Swartwout, double-angle type, steam separators, recently constructed for the Utah Copper Company, the largest copper smelting plant in the world, located at Garfield, Utah.

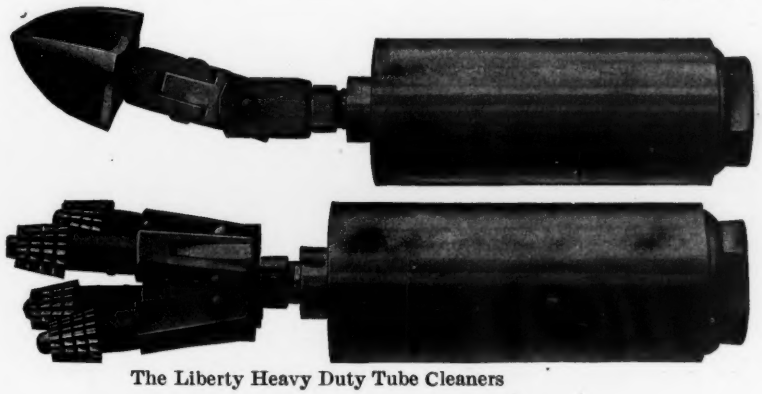
As will be noticed, the separator is constructed upon the principle of centrifugal force. The steam comes in contact

A Large 14-inch Swartwout Separator weighing 3750 pounds. to be used at the Utah Copper Co.'s Plant, Garfield, Utah

with a helical worm, causing it to rotate violently, thus developing centrifugal force, which hurls the water to the peripheral walls of the separator, when by gravity it is deposited at the bottom of the receiver and escapes through a drip pipe.

These three large separators, which weigh 3750 pounds each, are only a part of the entire order, which included 16 Swartwout steam separators and two 36-inch Swartwout exhaust heads. The exhaust heads operate upon the same principle as

the separators and force or rotate the water from the steam through a helical guide, the arrangement of parts being such as to give them a compact and ornamental appearance. These exhaust heads and separators, which are built for a working pressure of 175 pounds, were manufactured by the Ohio Blower Company, Cleveland, Ohio.



The Liberty Heavy Duty Tube Cleaners

The Liberty Heavy Duty Tube Cleaner.

The latest improvements of the Liberty heavy duty tube cleaner have made it possible to reduce the water consumption of the cleaner to a minimum so that the efficiency of the turbine is increased to such an extent that with a given amount of water, the power developed has been doubled and the time required to clean a tube is correspondingly reduced.

The latest types of Liberty cleaners embodying these new features are shown in the accompanying illustrations. The parts are all made heavy from the best material available. The turbine is cut out of a solid piece of steel and the bearings are made extra long and heavy. The durability and wearing qualities of these machines are such that it is said that one machine has cleaned over 4000 tubes in one plant without any expense for repairs.

The cleaners will stand any water pressure up to 500 pounds, and with 150 pounds pressure, it has been found from actual test, that the turbine develops over three horse power. As a result of this power, competitive tests have shown that the heavy duty cleaner will clean a tube in one-half the time required by other types. The Liberty Manufacturing Co., 6409 Susquehanna Street, Pittsburg, Pa., are the manufacturers, who furnish the cleaners with a freely swinging arm head and knocker or a drill as shown in cuts.

Goetze's Seamless Copper Gaskets with Graphite Covering.

The accompanying illustration shows a solid seamless copper gasket, which is lined with a preparation of graphite which is especially adapted for use in unions. It is impervious to oils, superheated and saturated steam, and hot and cold water lines, and will withstand high or low pressures with safety on account of its solidity. These profiled copper gaskets are made to suit the various sizes of standard unions from ¼ to 3 inches.

The American Goetze-Gasket & Packing Co., 725 East Fourteenth Street, New York, who manufacture this gasket, also make a sheet packing called Goetzerit for those who want to cut the gaskets themselves. This packing is composed of asbestos fibre, closely interwoven and impregnated with an unctuous substance, which is said to make it impervious to superheated as well as saturated steam, and to acids, oils, ammonia, gas and alkaline. It is also claimed that this packing does not squeeze out under pressure, thereby preventing the reduction of area of clear passage-way through the pipe, and that it cannot be blown out by the highest pressures used in practice.

Goetze's Seamless Copper Gasket with Graphite Covering

Book Reviews.

Henley's Twentieth Century Book of Recipes, Formulas and Processes. Edited by Gardner D. Hiscox. Size 6½ x 9½. 790 pages. Published by the Norman W. Henley Publishing Co., New York City. Price $3.00.

This book includes in its scope about ten thousand formulas and recipes, among which are many which are needful to the mechanic, the manufacturer and the artisan at some time in his business. A few of the subjects treated include bleaching, etching and engraving, glass making, paper, paints, rubber, explosives, gilding, galvanizing, bronzing, tinning, silvering, plating, enameling, varnishes, polishes, amalgams, alloys, solders, rust preventives, lubricants, oils, dyes, dryers, waterproofing, fireproofing, metallurgical formulas and casting.

For a reference book, this book should prove most useful to any person in any line of business who does things, as there is scarcely a substance employed in any of the arts and manufactures the preparation of which is not fully explained.

Electric Wiring and Construction Tables, by Henry C. Horstmann and Victor H. Tousley. Pocket-book size, with flexible cover. 120 pages and numerous tables. Published by Frederick J. Drake & Co., Chicago, Ill. Price, $1.50.

This book contains, as its title indicates, electric wiring tables, and tables which will aid engineers and contractors in the construction of the wiring itself. The book contains tables for direct current calculations, tables for alternating current calculations, tables showing the smallest wire permissible with any system, number of horse power or number of lights, tables for calculating the most economical wire loss, tables and diagrams showing proper size of conduits to accommodate various combinations of wires, and tables and data for estimating the quantity of material required in different lines of work.

Very little theoretical knowledge is necessary to understand the book, and it should prove valuable to anyone having wiring of any kind to perform.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

"Wiltbonco" engineering specialties and Klinger Reflex Water Gauges are illustrated in a very attractive catalog issued by Jerguson Mfg. Co., 221 Columbus Ave., Boston, Mass. All the specialties shown in this catalog are of the highest grade, and embody some rather unusual and very excellent features which make them worth getting acquainted with. In the Klinger water gauge the water shows black and is easily seen. One of these catalogs will be mailed to any reader sending his address to the address given above.

The Ideal Chain Pipe Wrench is becoming highly popular with engineers, because of its easy adaptabilities to a great variety of conditions that most other wrenches are unable to cope with. The Ideal will grip flanges, fittings, round, square or irregular castings easily and firmly. A circular describing this wrench in detail and showing several good cuts of it will be sent to any reader by the makers, Nason Mfg. Co., 71 Fulton St., New York City.

The big double page ad of Red Star Boiler Compound in this issue is a beauty, isn't it? It takes courage to buy space like that, and no firm would do it unless they knew their product to be good. The proposition to furnish each customer with a boiler compound feeder free of charge will be appreciated by engineers as a convenient and economical appliance.

The Wright Automatic Engine Stop and Speed Limit is described in a catalog received from J. K. Wright, 136 Liberty St., New York City.

W. Clifford Smith, manufacturer of Smith's Pipe Clamps for stopping leaks in steam and water pipes, has moved to larger quarters at 652 North Camac St., Philadelphia.

The Buckeye Boiler Skimmer Co., of Toledo, Ohio, have received the following letter from the Defiance Machine Co., of Defiance, Ohio:

Gentlemen:—Answering your communication of December 31st, will say, that we are delighted with the several skimmers which you connected with our boilers. We are using two equipments in connection with the two 100 horse-power boilers. They keep our boilers clean, and the saving which they have effected to us in our boiler compound alone during the course of one year would more than pay for the skimmers, and we do not see how anyone using boilers could afford to be without your device, as it certainly is a practical common sense apparatus.

Awaiting your further commands, we remain,

The Defiance Machine Works.

The Cherry Chemical Co., 10 No. 19th St., Philadelphia, advise us that they have received very good results from their advertisement, which has been running in THE PRACTICAL ENGINEER for several months, and which is repeated again on page 51 of this issue.

The Chicago office of the American Steam Gauge & Valve Mfg. Co., which has been located for the past twenty years at No. 16 No. Canal Street, have removed to new and commodious quarters at No. 7 to 9 South Jefferson Street, where, with increased floor space, they will be able to carry a much larger stock of their staple goods and specialties than ever before. A large assortment of gauges of every description, a complete line of brass for safety valves, water relief valves and indicators will be carried in stock at all times.

Owing to the increased business of the company they were compelled to move in larger quarters, and at the new location will be able to supply the trade in a very satisfactory manner.

The Buffalo Forge Co. has recently contracted to furnish two specially designed fans to furnish forced draft for the automatic stokers of the American Stoker Co., which will be used in the new steam plant of the General Electric Co. at Schenectady. The fans will be direct-connected to high speed motors through Buffalo flexible couplings. The reason for making the fans of special design were the desirability of using as high a motor speed as possible, to make the motor requirements as near standard as possible and the fact that space requirements called upon each of the blowers to handle 80,000 cubic feet of air per minute at 2.5 ounces pressure.

The Indicator Catalog issued by Jas. L. Robertson & Sons, 40 Warren St., New York, is one of the finest we have seen. It is artistically printed on fine coated paper and illustrated with numerous halftone cuts of Indicators assembled and in parts. It also shows the Victor Reducing Wheel and the Willis Planimeter, and gives a deal of information of value to the indicator student. Those who contemplate purchasing a new instrument should write for a copy.

A Great Opportunity

FOR ENGINEERS IN CHARGE

Thompson's Dynamo Electric Machinery

LATEST EDITION

In 2 large volumes, containing 1864 pages, 1119 illustrations, 19 pages of colored wirings and 56 large folding drawings.

This is the most complete and authoritative work on Direct Current and Alternating Current Dynamos and Motors.

SEND FOR SPECIAL EASY PAYMENT OFFER

Spon & Chamberlain
123 P. E. Liberty St.,
NEW YORK

The Perfection Grate Co., corner of Lyman and Chestnut Streets, Springfield, Mass., have issued an illustrated circular which has some interesting features. It describes the Perfection Grate, of which it says: "It will evaporate more water to the pound of coal than any other system in the world." That's a strong claim, one that's worth calling them on. If they can do it you want their grate; everybody wants it. If they can come close to it, most engineers will want it; but they claim still other things, and the success they are meeting with seems to indicate that they are making good. In any case the circular is worth reading, and we presume they will mail one to any one who writes for it.

WANTED—First-Class Engine Erectors. Permanent positions. Large concern. Address Box 6, Practical Engineer, 46 N. 12th St., Phila.

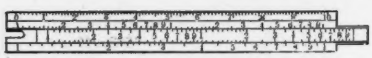
Wanted Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address
FRANCE PACKING Co., Tacony, Phila., Pa.

FOR SALE— A fully equipped machine shop, building steam engines and ice machines. Modern buildings, large grounds, and railroad siding. Plenty of orders ahead. Location eastern Pennsylvania. A good opportunity for a mechanical engineer. Box 8, The Practical Engineer, 46 N. 12th Street, Phila.

FOR SALE—Cyclopedia of Modern Shop Practice. A complete reference work for Machinists, Foundrymen, etc. Leather binding. Four voltumes. Cost $18.00. Will sell for six dollars. Address P. E. L., Box 425, Chicago, Ill.

ENGINEERS. Send your address, and *who employed* by, and we will send you a *Set of Corliss Valve Rod*, or *Throttle Valve Stem Packing free of charge. Express prepaid.* Give *Diameter of rod, Gland, and depth of box.* Ideal Metallic Packing has no *equal.* We have the documents to prove it. Ideal Metallic Packing Co., 419 Mackubin St., St. Paul, Minn.

RUNNERLESS SLIDE RULE



solves any of the three following proportions in a single setting:

$a : b = c : d$, $a : b = c2 : d$, $a2 : b = c2 : d$.

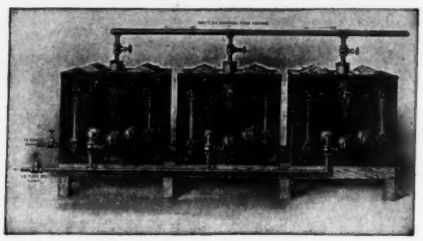
F. F. NICKEL, 27 Winans Street,
East Orange, N. J.

PATENTS
20 years experience. Inventors' Guide Book Mailed FREE.
O'MEARA & BROCK, Patent Attys., 918 F. Street, Washington, D. C.

PATENTS Watson E. Coleman, Patent Attorney, Washington, D. C. Advice free. Terms low. Highest ref.

PATENTS
C. L. PARKER
Attorney-at-Law and Solicitor of Patents
Patents secured promptly and with special regard to the legal protection of the invention.
Handbook for inventors sent upon request.
186 Dietz Bldg., Washington, D. C

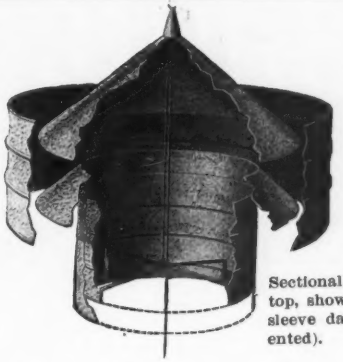
Power-Plant Necessities That Are Economizers



Unit Oil Filters Save Half The Oil Expense

Take your so-called "waste oil" and pass it over to a "Unit." You will get it back pure, clean and ready for use again. This process can be repeated again and again, saving 50 to 90 per cent. of your oil expense.

Send for our 64-page catalog. It's the most attractive ever published and describes our line fully.



Sectional view, glass top, showing sliding sleeve damper (patented).

The Burt Ventilator Is Also A Skylight

Even when closed tight it admits light. It allows all hot air, smoke, steam, etc., to pass out freely. The round, sliding sleeve damper collects no dust or refuse, and is not affected by air currents. Also made with metal top instead of glass. Ask for full details.

Save The Roof The Burt Exhaust Head

is the best device known for muffling the exhaust pipe, and for separating all moisture and oil from the escaping steam.

The Burt Exhaust Head quickly and easily saves its cost by keeping the roofs and walls from premature decay and disfigurement. It does away with repair bills, and saves fuel, by returning the condensation directly to the boiler.

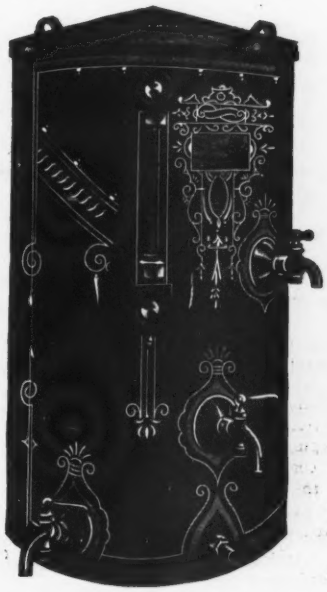
The Baldwin Locomotive Works have 53 Burt Exhaust Heads in use at their plant. If there were a better or more durable exhaust head made, they would surely know about it, and order it. The United States Steel Corporation has 95 of them.

Wash Old Oil In Water! The Cross Oil Filter

strains oil through waste and then washes it in pure heated water. This makes lubricating oil dirtless and gritless.

This filter costs but a few cents a year to maintain —the saving it effects is limited only by the amount of oil you use.

Send for beautiful catalog.



The Burt Manufacturing Company, Largest Manufacturers of Oil Filters in the World
204 MAIN ST., AKRON, O, U. S. A.

ALSO SUPPLIED BY ENGINE BUILDERS, DEALERS AND POWER CONTRACTORS

On Wednesday evening, March 13th, Mr. Edward C. Brown, while on a visit from the Hawaiian Islands, delivered a very interesting address at a meeting of Northeast Association No. 20, N. A. S. E., of Philadelphia. Mr. Brown's remarks appertained to the geographical location of the islands, and their value to the United States Government as a strategic point in time of war, also the resources of the islands, dwelling most particularly on the sugar industry and mentioning the standing of the stationary engineers with whom he is quite familiar, and describing some of the largest plants.

An exceptionally handsome new catalog containing half-tone cuts and a complete description of Sterling Metallic Packing has been issued by Sterling Metallic Packing Co., Troy, N. Y.

York Manufacturing Co., York, Pa., has recently closed contracts for the following installations: A 50-ton ice plant for the Rochester Cold Storage and Ice Co.; a 20-ton refrigerating and ice making plant in the Power Hotel, Rochester, N. Y.; a 25-ton ice-making plant for the Fayetteville Ice and Mfg. Co., Fayetteville, N. C.; a 125-ton compression side and brine cooling system for the Central Lard Co., Jersey City, N. J.; a 50-ton ice plant for the Muskogee Ice and Power Co., Muskogee, I. T.; a 125-ton compression side and brine cooling system for Conron Bros., New York., N. Y.; a 50-ton ice-making and cold storage plant for the Associated Ice Co., Beverly, Mass.; a 125-ton compression side for the Congress Brewing Co., Brooklyn, N. Y.; two 40-ton refrigerating machines and a 25-ton ice-making plant and brine cooling system for the Latrobe Ice and Provision Co., Latrobe, Pa.; a 125-ton compression side for the Eagle Brewing Co., Newark, N. Y.; a 100 compression side for the Burkhardt Brewing Co., Boston, Mass.; an ice plant of 100 tons capacity for McCann Bros., Philadelphia, Pa.

The Collins Regulator Co., 55 Second Ave., Conshohocken, Pa., are selling Collins Damper Regulators on a guaranteed coal saving. Full particulars regarding their proposition may be had by writing to the address given above.

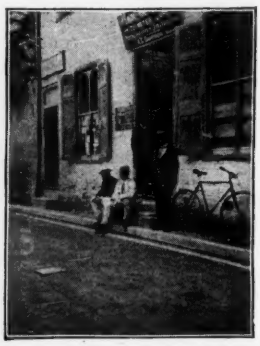
Jerguson Manufacturing Co., Boston, Mass., has recently equipped the boilers of the U. S. cruisers "Salem" and "Birmingham," building at the Fore River Shipbuilding Co.'s yards, Quincy, Mass., with Klinger reflex water gauges, Wiltbonco mountings and Wiltbonco-Navy gauge cocks.

Lubron Hydraulic Compound is said to be a splendid thing for hydraulic elevators; mixed with the water in the tanks it lubricates the pistons, cylinders and valves, causing a very noticeable improvement in their running and keeping all parts touched by the water in perfect condition. It is said that it will increase the speed of elevators as much as twenty per cent. It is manufactured by Knowlton Packing Co., 14 L St., South Boston, Mass. Catalog and sample will be sent to those interested upon request.

Metallic packings are interestingly discussed in a booklet issued by the United States Metallic Packing Co., 429 North Thirteenth Street, Philadelphia. The booklet is devoted chiefly to a description of the Standard Class No. 1 packing, made by the company for stationary and marine service. A new and decidedly interesting feature of the booklet is the new Ideal method for lubricating their packings. By this method oil is introduced into the supplementary gland and entirely surrounds the rod between the two sets of packing rings. A copy of the booklet will be mailed to any reader upon request.

Engineers' Firing Tools! That's something that ought to interest every engineer, for good tools help to make good fires; and good firemen and nearly every engineer knows how hard it is to get good tools. Joseph G. Pollard has been making engineers' firing tools for many years, knows how to make them, how to shape them and how to temper them. He has just issued a new circular and price-list of his tools, which he will send you if you write him. Address Joseph G. Pollard, 141 Raymond St., Brooklyn, N. Y.

The Geo. W. Lord Company report that their branch in Kingston, Jamaica, while suffering severely from the earthquake, was unusually fortunate in that no lives were lost. The Manager, Mr. Davidson, and his assistants escaped to the street at the first alarm, and although considerable damage was done the building, only the stock on hand in the sample room was injured, all goods in warehouses being saved. A great deal of small



personal property was looted by the natives. The branch was especially fortunate in having in storage the only available supply of lubricating oils on the island, and consequently they have been doing a land office business in the region of the earthquake. The Kingston branch was the chief distributing office of the West Indies for Lord's Boiler Compounds until this catastrophe. Since then, the branch at San Juan, Porto Rico, has had to carry the bulk of the business.

The Rickards-Corliss Engine Works, 4041 No. Fifth Street, Philadelphia, have just completed the installation of two Rickards-Corliss engines at the Southern Manual Training School, Broad and Jackson Streets, Philadelphia.

The Keystone Lubricating Co. have a liberal offer to engineers set forth on the front cover of this issue of THE PRACTICAL ENGINEER. A sample can of Keystone Grease, a brass grease cup and an engineer's cap, all free, express prepaid, to any address. A mighty liberal proposition, and yet the makers say it has paid, for in this way many engineers have been persuaded to test Keystone Grease; and after once testing it they almost invariably continue using it, so that it has led to an enormous demand which is already taxing their new factory to the limit of its capacity.

The New England office of the Williams Gauge Co. has been moved from the Tremont Building to No. 10 Oliver Street, Boston, which is in the midst of the machinery district, and is a decidedly better location for a steam specialty business. Mr. H. Elliott is their New England manager.

The Locke Regulator Co., of Salem, Mass., advise us that the suit of the Consolidated Engine Stop Co. vs. the Locke Regulator Co., over an engine stop patent, has been decided in favor of the Locke Regulator Co.

A sample spool of Palmetto Packing will be mailed free to any reader who wishes to give it a trial and who will take the trouble of writing to Green, Tweed & Co., 109 Duane St., New York.

The Vigilant Feed Water Regulator for regulating the admission of water to steam boilers is fully described in a catalog issued by Chaplin-Fulton Mfg. Co., Pittsburgh, Pa.

In this issue the merits of Stephenson Bar Belt Dressing are set to music—real music composed for the purpose. In the piano part one can hear the noise of the machinery "as plain as day." The man who wrote the words evidently knows how to avoid trouble from slipping belts, and he knows how to write poetry also.

The Holmes Metallic Packing Co., Wilkes-Barre, Pa., advise us that they applied their metallic packing to the first new engine that went into San Francisco after the fire.

The Unique Turbine Atmospheric Exhaust Steam Condenser shown in an advertisement on page 78 of this issue is well named. for it is indeed unique, and the service which it is proposed to perform with it suggests immense possibilities for economy. Circular and full particulars regarding cost of installation will be sent to any one writing the Unique Engineering Co., 100-102 Hinsdale St., Brooklyn, N. Y.

USUDURIAN packing is one of the oldest brands of sheet packing now in use. It is a familiar name to engineers of long experience, but owing to its not having been advertised very extensively of recent years, it will be new to many of the younger engineers. Usudurian is an unvulcanized, self-vulcanizing rubber sheet. It is said to be especially good for joints that are so uneven as to require building up or doubling on one side for the reason that it can be pieced by applying a little naptha to the surface so that under pressure it becomes as solid as one piece. All scrap may be sold again to the manufacturers. A catalog describing Usudurian fully, and also a sample of the packing will be mailed to any engineer mentioning THE PRACTICAL ENGINEER. Address Revere Rubber Co., 71 Kingston Street, Boston, Mass.